AGRICULTURAL SOCIETY OF NIGERIA (ASN)

57TH ANNUAL CONFERENCE PROCEEDINGS

THEME:

STRENGTHENING AGRICULTURE FOR FOOD AND NUTRITION SECURITY, MARKET DEVELOPMENT AND EXPORT IN A CLIMATE CHANGE ENVIRONMENT

"LAFIA 2023"

DATE:

23rd – 27th October, 2023.

VENUE:

FEDERAL UNIVERSITY OF LAFIA,

NASARAWA STATE, NIGERIA

EDITORS:

AJAYI, F. A., RAHMAN, S. A., USMAN, A., IBRAHIM, A. J., ADEJOH, S. O., KANA, H. A., OKUNSEBOH, S. A., OGAH, G. O., ZAKNAYIBA, D. B. AND OKOYE, B. C.

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STRENGTHENING AGRICULTURE FOR FOOD AND NUTRITION SECURITY, MARKET DEVELOPMENT AND EXPORT IN A CLIMATE CHANGE ENVIRONMENT

Proceedings of the 57th Annual Conference of the Agricultural Society of Nigeria (ASN)
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Protocols/Salutations

It is my honour and privilege to welcome you all to the 57th Annual Conference and General Business Meeting of the Agricultural Society of Nigeria (ASN). An event that takes place annually and hosted by worthy ambassadors of the Society. It gladdens my heart to stand here to welcome you to Federal University of Lafia as a worthy member of the Society and as a Fellow of this noble profession. Agricultural Society of Nigeria, as we all know is an umbrella that shields all other professional societies that has to do with the profession of our fore fathers, i.e. Agriculture. No nation, talk less of individuals that can survive without food albeit agriculture.

The Society was founded on the premise of improving the study and science of agriculture. As the theme of this year conference suggests: "*Strengthening Agriculture for Food and Nutrition Security, Market Development and Export in a Climate Change Environment". You will agree with me that the theme of this year conference is apt in view of the changes that are happening in the world and the need to secure food and nutrition for everybody. I believe we the scientists in the fore front of improving food and nutrition will proffer solutions to the challenges the world is facing at this conference. I want to thank everyone that has joined the battle in improving food and nutrition security in a changing economy and global warming.*

I therefore, welcome you all to Lafia the capital City of Home of Minerals and in fact Home of Peace as the name suggests, Lafia is Peace.

You are all welcome.

Thank you.

PRESIDENT'S ADDRESS

ADDRESS BY PROF. JUDE A. MBANASOR *FASN, FASN, FNAAE, FSM*

THE NATIONAL PRESIDENT OF AGRICULTURAL SOCIETY OF NIGERIA AT ITS 57TH ANNUAL CONFERENCE HOLDING AT

FEDERAL UNIVERSITY OF LAFIA, NASARAWA STATE FROM OCTOBER 23RD - OCTOBER 27TH, 2023.

PROTOCOL

On behalf of the National Executive Council, I am most delighted to welcome you to this 57th Annual Conference of Agricultural Society of Nigeria holding at this serene city of Lafia. I am most grateful to His Excellency, the Governor of Nasarawa State, Alhaji Abdulahi Sule, the government and people of this peace loving state for availing us of the opportunity to host this conference here. Let me also acknowledge in a special way, the assistance of our Chief Host, the Vice-Chancellor of the Federal University of Lafia, Prof. Shehu Abdu Rahman towards making the conference a reality. I am grateful to Prof. Garba Hamidu Shanubutu, the Executive Secretary, Agricultural Research Council of Nigeria for accepting to be the Keynote Speaker. To other lead speakers. I say welcome. I also commend the Local Organizing Committee for assiduously working hard for the realization of this conference. I am most grateful to God for the travelling mercies He granted each and every one of us to be at this conference.

Your Excellency, distinguished guests and my esteemed colleagues, let me refresh our minds, especially for the benefit of those who do not know, that our Society was founded sixty one years ago, making us one of the oldest professional bodies in Nigeria. Many Nigerians may not be aware of this due to the fact that we make our contributions to nation building quietly.

However, it is worthy of note that Agricultural Society of Nigeria was set up as an umbrella body for all practitioners to assist in fostering cohesion in the quest for excellence in the execution of our professional mandate. We also collaborate with national and international authorities to enhance exchange and dissemination of knowledge in all areas of agriculture. Through conferences such as this, we harvest ideas and transmit same to policy makers in a bid to assist government make progress in food production.

Our theme for this year's conference which is "*STRENGTHENING AGRICULTURE FOR FOOD AND NUTRITION SECURITY, MARKET DEVELOPMENT AND EXPORT IN A CLIMATE CHANGE ENVIRONMENT*" is more than apt in combating challenges posed by a weak economy, dwindling foreign exchange, climate change and inconsistent government's policies.

The germane question is… how do we strengthen agriculture to achieve the results that we desire? From research carried out by our members, the results showed that Nigeria has one of the most arable lands in the world. It was also shockingly discovered that farming activities are taking place only in about one quarter of this huge available land. Similarly, 90 percent of the activities are being undertaken by subsistence farmers. In this scenario, the food and nutrition security we seek may remain elusive except something drastic is done.

The society was happy when His Excellency, President Bola Ahmed Tinubu announced that the Federal Government was declaring a state of emergency on food security. We not only welcomed the idea but announced our availability to collaborate with the government for the realization of that bold policy initiative. For now, we are still awaiting the government's response, especially now that ministers have assumed office.

Most, if not all, of our members are employees of government, either as teachers or researchers. Over the years, we have worked very hard in policy formulation aimed at strengthening agriculture in Nigeria. But it is most unfortunate that some of us are really frustrated because of the scant attention paid to our works. I will not exactly say that the results of our research works are gathering dust in government's offices, but I believe that if policy implementors hasten to apply our suggestions, solutions would be found quickly to the lingering challenges before us in the agricultural sector. Be that as it may, it is not yet late for the government to work closely with our members in the development of policy initiatives that would be productively applied for the overall acceleration of food security in Nigeria.

Another area of interest is funding for researchers. Most times, due mainly to paucity of funds and bureaucratic bottlenecks, research grants are not readily made available to our members. The little that TETFUND releases to universities and other institutions of higher learning is hardly enough to go round. In this respect, I call on well to do corporate organizations to support the government in the funding of researchers in Nigeria. That is the way to go if we are to achieve the much anticipated food and nutrition security we crave. On our part, we shall not relent in encouraging our members to improve upon their capacity and knowledge in tackling new frontiers in agricultural research.

Indeed, I believe that from the quality of papers lined up for presentation and the attendant technical sessions, the 57th conference of our professional body will come out, once again, with far reaching proposals and recommendations that will see our nation march forward in its quest for self-sufficiency in food production. Because we are also not omniscient, we shall gladly welcome ideas on how to make our jobs better.

Once again, I welcome all of us to the 57th Annual Conference of Agricultural Society of Nigeria holding in Lafia. I also thank His Excellency for being a gracious host.

Thank you so much and may God continue to bless all of us

Prof. Jude Mbanasor *fasn, fnaae, fsm*
National President

KEYNOTE ADDRESS:

TRIPLE HELIX AND INTEGRATED RESEARCH: A CATALYST FOR STRENGTHENING AGRICULTURE FOR FOOD SECURITY, MARKET DEVELOPMENT AND EXPORT IN A CLIMATE CHANGE ENVIRONMENT

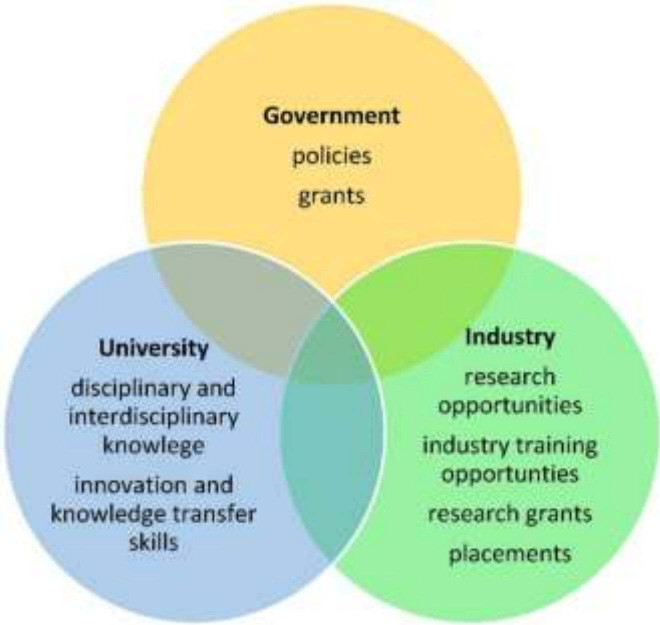
Professor Garba Hamidu Sharubutu
Executive Secretary, Agricultural Research Council of Nigeria (ARCN),

1.0 INTRODUCTION

1.1 Triple Helix: The triple helix is a model of innovation that refers to a set of interactions between academia, industry and government to foster economic and social development. It is also a model of collaboration between university, government and business. This model has attracted considerable attention in both developed and developing economies as an integral policy making tool to enhance innovation and promote economic development (Etzkowitz and Dzisah, 2008).

Studies of the factors driving economic growth has received considerable attention, especially now when sustainability is the main focus of the scientific discourse. It is evident that alternative sources of economic growth are required (Etzkowitz *et al*., 2007), since technology transfer has not lived up to expectations and failed to lead to sustainable economic growth (Saad *et al*., 2008). Researchers have discovered that entrepreneurial activity and innovation are key drivers of economic growth. Consequently, industrial societies have gradually transitioned to knowledge-based, thus creating a new social order the "Triple Helix" (Etzkowitz, 2002; Caceres-Carrasco and Guzman-Cuevas 2010; Galindo-Martin *et al*., 2010; Cai and Etzkowitz, 2020).

A keynote Address by the Executive Secretary, Agricultural Research Council of Nigeria (ARCN), at the 57th Annual Conference of the Agricultural Society of Nigeria on 24th October 2023 at Federal University Lafia, Nasarawa State.



The triple helix theory provides a general paradigm, analytical framework, and method for studying the relationship between innovation actors at the system level (Strand *et al*., 2017). Specifically, it advocates the strengthening of the collaborative relationships between academia, industry and government to improve innovation. A good, working relationship between the three partners of the triple helix can lead to a productive research environment, and enhance innovation and economic development in a country or region. The triple helix plays a crucial role in integrating the universities, firms, and governments whose close interaction and optimal collaboration enable nations to anticipate how they could create wealth and build a knowledge-based society (Sarpong *et al.*, 2017). Although, sustainable development and technological advancement can hardly be isolated from each other, a significant challenge in attaining a harmonious and mutually reinforcing dynamic between them, while minimising the adverse social and economic effects such as resource depletion, environmental degradation, escalating inequality and population explosion is of enormous importance to humanity (Zhou and Etzkowitz, 2021).

1.2 Integrated Research:

The sustainability challenges confronting humanity are incredibly complex and are thought to necessitate integrated transdisciplinary approaches (Morales, 2017) and (Luthe, 2017). Consequently, scientists are increasingly being asked by funding bodies to develop large, integrated research programmes (Hoffmann *et al.*, 2017). These integrated programmes are expected to encompass multiple projects involving various disciplines and stakeholders, and working towards a common goal (e.g., [Laursen and O'Rourke (2019) and Niesten *et al.*, (2021). Combining different projects into one integrated programme is expected to have several benefits such as avoiding duplication of efforts, creating synergies among projects, achieving better collaboration among researchers, realising efficiency gains and obtaining higher returns on invested funds (Lattanzio *et al.*, 2020). Moreover, large-scale integrated programmes can become expensive (e.g., by incurring high overhead costs), while they often fail to deliver the desired outcomes for stakeholders (Grigorovich et. al., 2018) and Wognum *et al.*, 2019). Communication, politics, power imbalances and hidden agendas often form major obstacles.

Integrated research from the perspective of agricultural development is synonymous with Integrated Agricultural Research for Development (IAR4D) promoted by Forum for Agricultural Research in Africa (FARA). The concept is based on the realization that researches are designed and implemented by teams drawn from different disciplines, institutions and stakeholder groups rich in knowledge to solve complex problems and meet multiple objectives. Besides, this is likely to come up with the full range of technological, policy and institutional options needed if a broader set of users is to support and benefit from change. (ICRA 1999). The defining principles of IAR4D include the following: -

i. IAR4D integrates the perspectives, knowledge and actions of different stakeholders around a common theme.
ii. It integrates the learning that stakeholders achieve through working together.
iii. Integrate analysis, action and change across the different (environmental, social, economic) 'dimensions' of development.
iv. It integrates analysis, action and change at different levels of spatial, economic and social organization.

Agricultural Research for Development is characterized by the following factors:

- Action research that is demand driven or problem solving.
- Participatory processes that include collective action at multiple levels (that is at community, organizational, policy, institutional, and agro-industrial levels);
- Stakeholders participation in identifying needs, strategies, and solutions to problems and in collective innovation systems involving joint learning and the generation of knowledge and research outputs;

- Systemic approaches integrating disciplinary and stakeholder perspectives and analysis and action at different levels (such as the farm, community, enterprise, district, and national levels);
- Teamwork and partnerships as mechanisms for solving complex problems by addressing issues that cut across sectors.
- Contributions to broader development goals as opposed to mere increases in productivity.
- Recognition that technological innovation is insufficient, and that research must lead to social, economic, and political reform if it is to bring lasting benefits.

2.0. STRENGTHENING AGRICULTURE FOR FOOD SECURITY IN A CLIMATE CHANGE ENVIRONMENT

The economy of any nation lies in its ability to develop key sectors that can drive sustainable production and create jobs. It was on this light that the United Nations in 2016 agreed on a common framework to address 17 Sustainable Development Goals (SDGs) to be achieved by 2030. Agriculture being the major pillar for every country to achieve food and security occupied the topmost SDGs 1 and 2 which addresses the ending of poverty and zero hunger, while climate change action against emission of greenhouse gas and clean energy security which is the backbone of industries are SDGs 13 and 7 respectively. In Nigeria, agriculture including forestry and land use are the highest contributor to GHG emission while energy sector is the second most contributor to emission of GHG. Curbing greenhouse gas emissions to mitigate climate change has proven to be a difficult objective, in large part because international coordination of the required mitigation efforts is very difficult. As a result, in a recent special report, the Intergovernmental Panel on Climate Change (IPCC) pointed out that limiting global warming to no more than 1.5°C (2.7°F) would require large reductions in emissions and important societal changes, although it remains within the realm of the possible (IPCC 2018). Given the difficulty of achieving these changes and the fact that past emissions alone are likely to cause some warming over the coming decades, adaptation to climate change will be necessary. As noted by Anderson et al. (2018) an upside of adaptation is that it does not rely on international coordination; individual countries, and even economic agents, can undertake adaptation, incentivized by environmental and price changes.

Nigeria's agriculture and food production systems are based on exploitation of natural resources, with extensive crop and livestock production systems, rain-fed agriculture, hunting, and fishing from natural water bodies. Climate change, in addition to non-climate drivers such as soil degradation, land tenure systems, and poor technology are expected to have significant impacts on these systems, and consequently on food security. In particular, climate change is expected to intensify existing problems and create risks in the environment.

Agricultural potential in Nigeria is still far from being developed to guarantee food security owing to many daunting challenges including low level of agricultural investment, huge post-harvest losses, lack of adequate infrastructure, rudimentary technologies, limited irrigation systems, weak agricultural advisory services, poor access to market, lack of finance and poorly developed National Agricultural Research System (NARS) and currently the vagaries of climate change. The most expedient way to achieving food security amidst climate change is by embracing and investing in climate smart agricultural research and technology dissemination/adoption processes. Climate related Innovative/cutting edge technologies have to be exploited and adopted in order to enable self-sufficiency in food availability and surplus production for commercialization in the future.

2.1. Role of Government on strengthening food security amid climate change environment.

i. **Policy development:** It is the responsivity of Government to develop climate change related policies to safeguard food security of the country. The following are some of policies existed in Nigeria.
   - National Agricultural Technology and Innovation Policy (NATIP) 2022 – 2027. The current policy of Federal Ministry of Agriculture and Food security. Promoting climate smart agriculture and nutrition are among the cross-cutting issues guiding the implementation of the ten (10) strategies earmarked to drive the Nigerian agriculture to achieve food security.
   - National Policy on the Environment (Revised 2016). The goal of the National Policy on the Environment is to ensure environmental protection and the conservation of natural resources for sustainable development. Its strategic objective is to coordinate environmental protection and natural resources conservation for sustainable development.
   - Climate Change Act, 2021: The Act provides a framework for mainstreaming of Climate Change actions, provide for a system of carbon budgeting and the establishment of the National Council on Climate Change. The Act also provides a framework for achieving low greenhouse gas emission Objectives. Funding and grants
   - Tertiary Education Trust Fund (TETFUND): Established by Education Tax Act Cap. E4, Laws of the Federation of Nigeria, 2004 and Education Tax Fund Act No. 17, 2003 charged with the responsibility for imposing, managing and disbursing the tax to public tertiary institutions for education and research.in Nigeria.
   - National Agricultural Development Fund: Established by Act of the national assembly in 2023 to provide for agricultural development in Nigeria.

ii. Regulation:
   - Agricultural Research Council of Nigeria (ARCN): Has the mandate for coordination, supervision and regulation of agricultural research, training and extension services in Nigeria. This include research on climate change impact, mitigation and adaptations methods.
   - National University Commission (NUC): The main functions of the Commission among others include granting approval for all academic programmes run in Nigerian, ensure quality assurance of all academic programmes offered in Nigerian universities and channel for all external support to the Nigerian universities.
   - National Biosafety Management Agency (NBMA): Regulating food safety including genetically modified products.
   - National Biotechnology Development Agency (NABDA): Regulate biotechnology application and uses in Nigeria.

iii. Establishing innovation incubation centres
   - National Office for Technology Acquisition and Promotion (NOTAP). The mandate is evaluation /registration of technology transfer agreement, patent and promotion of intellectual property, technology advisory and support services, commercialization of R&D results and research industry linkage.

iv. Other activities of government include provision of Infrastructural support, advisory services, engagement of university research, research fellowship support and patent licensing.

2.2. Role of Academia/Agricultural Research Institutes on strengthening food security amid climate change environment.

i. Research and development:
   - *Research into development of biofortified products such as pro-vitamin A cassava, quality protein maize, pro-vitamin A maize, industrial sorghum and orange fleshed sweet potatoes.*
   - Development of climate resilient crops and livestock breeds. Eg. Drought, heat, flood and pest tolerant varieties,
   - Improvement of nutritious indigenous crops and livestock breeds.
   - Research into early planting and early maturing crops
   - Research into land use on crop suitability

ii. Education: Transmission of knowledge, skills, and character traits to populace including knowledge on food, nutritional products and climate change impact.

iii. Spin offs/Consultancy services.

iv. Incubation: The process to create, perfect and commercialize technologies from technological ideas or scientific research and technological development results or from unfinished technologies through assistance activities in terms of necessary technical infrastructure, resources and services.

v. Other roles of universities include joint projects, Joint patent, spin offs, Contract research, Training and development and New product idea/innovation.

2.3. Role of Industry on strengthening food security amid climate change environment.

i. Offtakers of research technology: Industries commits to partially or wholly purchase output from a research technology.

ii. Product and service development: Involves strategic assessment of concepts and how it delivers value to the customers.

iii. Entrepreneurship venturing: The ability and readiness to develop, organize and run a business enterprise, along with any of its uncertainties in order to make a profit.

iv. Research grant: Offer *Research Grants* to supports education, research and technology generation.

v. Others include establishing industrial parks, creating research opportunities and industrial training opportunities

3.0. STRENGTHENING AGRICULTURAL MARKET DEVELOPMENT AND EXPORT IN A CLIMATE CHANGE ENVIRONMENT

Market and businesses in the agricultural, forestry and fishing sectors are most at risk of catastrophic climate change impacts because their operations rely on the natural environment. Climate change impacts business vary depending on industry, location and vulnerability such as what your business facilities are made from, and the services it depends on. Impacts of climate change on markets/business can be direct such as physical damage from floods or bushfires, or forced closures or indirect such as supply chain interruption by extreme weather conditions.

Given our collective failure to mitigate greenhouse gas emissions, the world will have to adapt to a certain level of climate change. This may mean that as climate change affects crops' yield potential, new patterns of comparative advantage, and hence new trade flows, will emerge.

3.1. Role of Government:

- Policies that create enabling environment for market development and export
- Establishment of institutions that promote market development e.g. Nigeria Export Promotion Council, Nigeria Export Processing Zones and free trade zones.
- Establishment of commodity boards e.g. Cocoa board.

- Creating access to finance. E.g. Establishment of Nigeria Import export bank.
- Regulation of cooperative associations.

3.2. Role of Universities/Research Institutes

- Technology development in adaptive role of changing varieties or planting times to escape climate change impact
- Research into reallocation of land to crops or other uses more consistent with the yield under the new climate.
- Research into intensification of crop production, agricultural product substitution in food demand.
- Research into crop substitution in livestock-feed demand e.g. converting previously crop cultivated land to pasture land to mitigate climate change impact.

3.3. Role of Industry

- Investment in climate adaptive technological development and research on industrial processes.
- Plan for carbon storage in the design of industries.
- Efficient use of resources and energy to reduce GHG emission.
- Immediate and active actions to environmental problems (mitigation).
- Promoting use of renewable energy.
- Developing market solutions example green packaging.

3.4 Effects of triple Helix in a climate change Environment

- Adaptation of Suitable crops and measures to climate change environment.
- Policy Enhancement on information generation for climate change.
- Early maturing crops for food Security in a climate change environment.
- Research development on sustainable agriculture and resolution of challenges faced by industries with a backup of government policy to adapt crops and animals to changing climate environment.

CONCLUSION

The advent of knowledge-based economies with a particular focus to the roles of Government, academia and industries played to drive sustainable economic growth has garnered attention in recent times. While the Government role is largely in the area of policies and regulations that provide conducive/sustainable environment for academia to generate improve research technologies to withstand the present and future shocks such climate change and for the industries is off take of such innovations to adapt to such shocks such as disruption of supply chain due climate change and transition to the use of renewable energies to mitigate climate change impact.

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LEAD PAPER 1

Engr. Bukar Bindir Ph.D

AGRICULTURAL SOCIETY OF NIGERIA (ASN)

57th Annual Conference

FEDERAL UNIVERSITY OF LAFIA,

P.M.B. 146, Lafia, Nasarawa State.

PROTOCOLS & APPRECIATIONS…

BINDIR – ASN, FED UNI LAFIA 2023

Engr Umar B. Bindir PhD (Cranfield)

FAEng, FNSE, FNIAE, FSESN, CEng, COREN®

FOUNDER/CEO, BINDIR KNOWLEDGE CENTER INTERNATIONAL
YOLA TOWN, ADAMAWA STATE

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BRIEF ON: UMAR B. BINDIR

- **YOLA TOWN, ADAMAWA STATE; BSc (Maid), MSc, PhD (UK)**
- **Agricultural Power & Machinery Engineering Specialist**
- **FAEng, FNSE, FNIAE, COREN®, CEng, NPoM, etc**
- **ACADEMIA (Local and International)**
- **INDUSTRY (Local and International)**
- **CIVIL SERVICE (Federal Government)**
  - **FEAP, THE PRESIDENCY (Director), NAPEP, THE PRESIDENCY (Director)**
  - **Federal Ministry of Sports & Social Development (Director)**
  - **Federal Ministry of Science & Technology (Director)**
- **DG/CEO, NOTAP (2009 – 2015)**
- **Secretary to Government Adamawa State (SGS) (2015 – 2019)**
- ***Director CIR, AFIT (currently on leave of absence)***
- ***National Coordinator-National Social Investment Programme***
- **SOCIAL ENTREPRENEUR**

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SOCIAL ENTREPRENEUR

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CAC
CORPORATE AFFAIRS COMMISSION
FEDERAL REPUBLIC OF NIGERIA
Certificate of Incorporation
558034

7

8

ICT/TRAINING HALL

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THIS "INNOVATION PROJECT" IS NOT ONLY ILLUMINATING,
IT IS SOCIALLY FULFILLING

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YOU ARE WELCOME TO PARTNER

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BUT………TODAY

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Nigeria
Good People Great Nation

STRENGTHENING AGRICULTURE FOR FOOD AND NUTRITION SECURITY, MARKET DEVELOPMENT AND EXPORT IN A CLIMATE CHANGE ENVIRONMENT

A LEAD PAPER PRESENTATION AT THE 57TH ASN ANNUAL CONFERENCE HELD AT THE FEDERAL UNIVERSITY OF LAFIA, NASARAWA STATE

MONDAY 23RD OCTOBER 2023

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Nigeria
Good People Great Nation

SCIENCE, TECHNOLOGY AND INNOVATION: IMPLICATIONS ON STRENGTHENING AGRICULTURE FOR FOOD AND NUTRITION SECURITY, MARKET DEVELOPMENT AND EXPORT IN A CLIMATE CHANGE ENVIRONMENT IN NIGERIA

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KEY PHRASES:

- **STRENGTHENING AGRICULTURE**
- **FOOD & NUTRITION SECURITY**
- **MARKET DEVELOPMENT**
- **EXPORT**
- **CLIMATE CHANGE ENVIRONMENT**
- **IN NIGERIA**

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IN REAL TERMS…

THE EFFECTIVE APPLICATION OF STI

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KEY (IMPLICATIONS):

- STRENGTHENING AGRICULTURE (ALL ASPECTS)
- FOOD & NUTRITION SECURITY (PEOPLE/SUPPLY CHAIN)
- MARKET DEVELOPMENT (JOBS, WEALTH, ECONOMY)
- EXPORT (TECHNOLOGY, STANDARDS, LOGISTICS)
- CLIMATE CHANGE ENVIRONMENT (NEW PARADYM)
- IN NIGERIA (MEANINGFUL)

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IS MAINLY MEASURED ON THREE THINGS

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1. **Absolute poverty** is **totally eradicated**
    - **BASIC EDUCATION**
    - **BASIC HEALTHCARE**
    - **POTABLE WATER**
    - **DECENT SHELTER**
    - **DECENT CLOTHING**
    - **ETC**

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1. <u>Absolute</u> **poverty** is **totally eradicated**
2. Every man, woman, and child in the Country should **have access**, **not just to basic minimum needs, but to all the opportunities** to lead a happy, safe and fulfilling life
   - **SKILLS & COMPETENCES**
   - **PRODUCTIVITY & JOBS**
   - **SAFETY & SECURITY**
   - **ETHICS (DISCIPLINE & RESPECT)**
   - **PLAY & ENJOYMENT**
   - **etc**

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29

1. <u>Absolute</u> **poverty** is **totally eradicated**
2. Every man, woman, and child in the Country should **have access**, **not just to basic minimum needs, but to all the opportunities** to lead a happy, safe and fulfilling life
3. Develop institutions to ensure that the country **emerges** as a **knowledge and a learning society** built on core values of development (***hard work, honesty, discipline, productivity, sincerity, and a collective sense of purpose***
   - ***WORLD CLASS INSTITUTIONS, GLOBAL COMPANIES, PRODUCTS & KNOWHOW, INNOVATIONS & COMPETITIVENESS***

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THE EVIDENCE:

THOSE THAT HAVE EFFECTIVELY DONE THESE 3 THINGS…

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- **DEVELOPED & RICH** 1ST

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WHAT THEY DID RIGHT INCLUDE…

- **National Policies (evidence based, practical and implementable) on moving ALL SECTORS)**
- **Vibrant Science, Technology and Innovation (STI) system**
- **Institutional Systems of Innovation (NSI)**
- **Sustained Research and Development (R&D) Investment**
- **If Raw Materials Endowed, adopt a value addition culture**
- **Prioritised Technology Acquisition Focus and Core Mentor**
- **Strong Intellectual Property (IP) culture/system**
- **Innovative, Deliberate and Intense Deployment of ICE-T**
- **Viable Research - Industry Linkage models**
  - **Hi-Tech companies, Efficient Technology Incubation, Science and Technology Parks, Research Parks, Innopolis, Technopolis etc**
- **etc**

KEY PERFORMANCE INDICATORS

- **GLOBAL TECHNOLOGY VISIBILITY**
- **GLOBAL OPS/COMPANIES**
- **GLOBAL KNOW-HOW, SKILLS**
- **GLOBAL INDUSTRIAL PRODUCT RANGE**
- **CAPABILITIES & SERVICES**
- **DYNAMIC CREATIVITY & INNOVATION**
- **etc…**

IN THOSE EARLY DAYS, ONLY, EUROPEANS & AMERICANS...

BUT THEN:
FOLLOWERS, LEARNERS, ADAPTERS...

WHAT THEY FOLLOWED, LEARNT & DID…

- National Policies (evidence based, practical and implementable) on moving ALL SECTORS)
- Vibrant Science, Technology and Innovation (STI) system
- Institutional Systems of Innovation (NSI)
- Sustained Research and Development (R&D) Investment
- If Raw Materials Endowed, adopt a value addition culture
- Prioritised Technology Acquisition Focus and Core Mentor
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- etc

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- DEVELOPED & RICH
- EMERGING RICH

1ST, 2ND

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THEIR KPIs ALSO…

- GLOBAL TECHNOLOGY VISIBILITY
- GLOBAL PRODUCT RANGE
- GLOBAL COMPANIES
- GLOBAL KNOW-HOW, SKILLS
- CAPABILITIES & SERVICES
- DYNAMIC CREATIVITY & INNOVATION
- etc…

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BUT MANY ARE YET TO REALISE TO FOLLOW, LEARN & ADAPT...

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WHAT THEY DID NOT DO WELL…

- National Policies (evidence based, practical and implementable) on moving ALL SECTORS)
- Vibrant Science, Technology and Innovation (STI) system
- Institutional Systems of Innovation (NSI)
- Sustained Research and Development (R&D) Investment
- If Raw Materials Endowed, adopt a value addition culture
- Prioritised Technology Acquisition Focus and Core Mentor
- Strong Intellectual Property (IP) culture/system
- Innovative, Deliberate and Intense Deployment of ICE-T
- Viable Research - Industry Linkage models
  - Hi-Tech companies, Efficient Technology Incubation, Science and Technology Parks, Research Parks, Innopolis, Technopolis etc
- etc

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- DEVELOPED & RICH
- EMERGING RICH
- *DEVELOPING/POOR*
- *LEAST DEVELOPED*
- *UNDERDEVELOPING*
- *UNDERDEVELOPED*

1ST, 2ND

3RD

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THEIR KPIs….

- NO REAL TECHNOLOGY VISIBILITY
- LOW PRODUCTIVITY
- FEW/NO GLOBAL ORGANISATIONS
- FEW/NO GLOBAL CAPACITY, SKILLS
- WEAK CAPABILITIES & SERVICES
- etc…

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SO….. HOW ARE ALL THESE RELEVANT TO NIGERIA??

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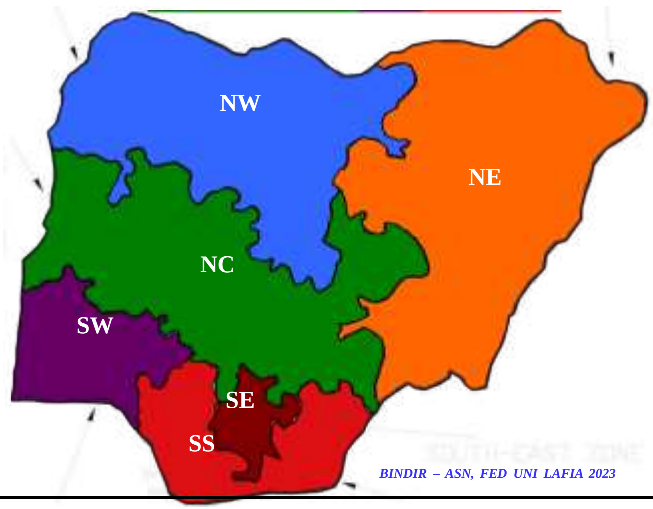
NIGERIA IN BRIEF



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FACTS & REALITIES

- POPULATION (Over 200 Million)
  - Young, English Speaking, Traditionally Entrepreneurial, etc etc
- RESOURCE BASE (Agro/Minerals/Water, Oil/Gas etc)
- WEAK INFRASTRUCTURE
  - Physical, Socio-economic
  - **Suffocating Education System**
- WEAK “LOCAL” **INDUSTRIES**
- **INSECURITY**/**CORRUPTION** CHALLENGES
- HIGH ABSOLUTE POVERTY (60/70%) – **> 110 MILLION**
  - **Dominance of weak Rural Life**
- EMERGING CHALLENGES OF **ENVIRONMENT**
- “MATURING” DEMOCRACIES, etc etc

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FACTS & REALITIES…

- **FEW OR NO GLOBAL PRODUCTS**
- **FEW OR NO GLOBAL COMPANIES**
- **FEW OR NO GLOBAL KNOW-HOW, SKILLS AND CAPABILITY SERVICES**
- **FEW “GLOBAL” TECHNOLOGIES**
- **Etc etc etc**

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SOBER REFLECTIONS & AGENDA!

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BUT….*THIS IS NOT REALLY NEW*

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PAST LEADERSHIP/POLICIES??

- OFN/GREEN REVOLUTION
- WAI, MAMSER, DFRRI, SAP…
- INDIGINISATION POLICY
- VISION 2010 *(mid 80s to late 90s)*
- VISION 20/2020 (NEEDS/MDGs, ECONOMIC REFORMS)
- VISION 20/2020 (7 – POINT AGENDA)
- VISION 20/2020 (TRANSFORMATION AGENDA)
- VISION 20/2020 (CHANGE MANTRA/SDGs)
- VISION 20/2020 (NEXT LEVEL)
- VISION 20/2030 *(Lifting 100 million/10 years out of poverty)*

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PAST LEADERSHIP/POLICIES??

- OFN/GREEN REVOLUTION
- WAI, MAMSER, DFRRI, SAP…
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- **VISION 2010** ***(mid 80s to late 90s)***
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ALL TARGETTED AT A NIGERIA THAT…

- IS EFFICIENT & PRODUCTIVE
- IS GLOBALLY COMPETITIVE
- HAS A MODERNISED SOCIETY & ECONOMY
- HAS A DYNAMIC POPULATION
- HAS A CREDIBLE GLOBAL VISIBILITY
- THAT IS SECURE AND SAFE
- HAS A VIABLE KNOWLEDGE ECONOMY

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BUT WE HAVE ALWAYS RETURNED WEAK SCORES!

SO WHY??

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THE CORE REASON ROTATES AROUND THE UNDERSTANDING THAT…

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ACHIEVING THESE:.....

- EFFICIENCY & HIGH PRODUCTIVE
- GLOBAL COMPETITIVENESS
- A MODERNISED SOCIETY & ECONOMY
- A DYNAMIC POPULATION
- A CREDIBLE GLOBAL VISIBILITY
- SECURED AND SAFE
- A VIABLE KNOWLEDGE ECONOMY

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FIRMLY DEPEND ON THE VIBRANCE, CONNECTIVITY AND EFFICIENCY OF OUR KNOWLEDGE CAPITAL HINGED ON:

AN DYNAMIC SCIENCE, TECHNOLOGY & INNOVATION ECO-SYSTEM

"THIS IS THE MASTER KEY"

(AND THERE IS NO CUTTING CORNERS)

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BASICS OF THE LECTURE...

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WE MUST UNDERSTAND THE THEORIES & PRACTICE OF THE STI VALUE CHAIN!!

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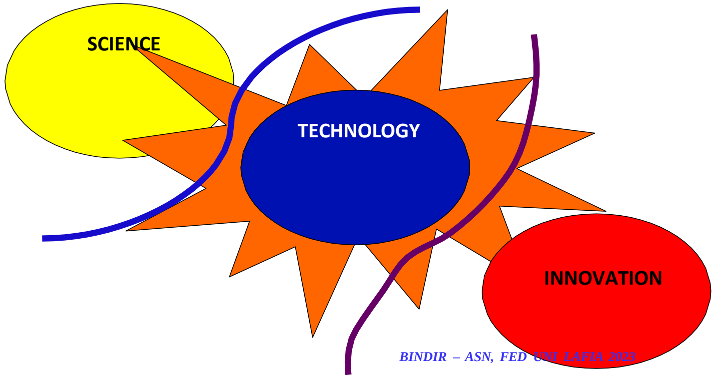
THE STI "ECO-SYSTEM"



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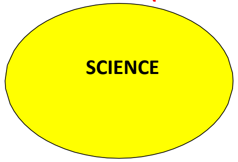
SCIENTIFIC CAPACITY (RESEARCH)

FACTS AND FIGURES (Research)



Ability to study, generate knowledge, discover, conceive possibilities, document, communicate, publish…

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RESEARCH

- **SPECIALISTS (SCIENTISTS/RESEARCHERS)**
- **HIGHLY TRAINED AND QUALIFIED**
- **"LONG TERM" INVESTMENTS**
- **EXPENSIVE TOOLS AND FACILITIES**
- **HIGH MOTIVATION**
- **etc**

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RESEARCH RESULTS/OUTPUT

- **RESEARCH INFRASTRUCTURE (Labs, Equipment & Centers)**
- **PhDs, WORLD CLASS PUBLICATIONS, PROFESSORS)**
- **HIGH IMPACT/CITATION/ACADEMIC PARTNERSHIPS…**
- **RELEVANCE?**

HIGH LEVEL, QUALITY KNOWLEDGE

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ENGINEERING CAPABILITY

POSSIBILITIES AND APPLICATIONS (Development)

ENGINEERING & TECHNOLOGY

Ability to transform knowledge (S) into socio-economic solutions and assets)

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TECHNOLOGY

- TECHNOCRATS (ENGINEERS, ARTISANS, HANDY CRAFT MEN/WOMEN…. OTHERS)
- HIGHLY SKILLED IN TRANSFORMING KNOWLEDGE
- PROOF OF CONCEPTS ON PRODUCTS AND PROCESSES
- PRODUCTION PROCESSES INFRASTRUCTURE
- PROTOTYPES AND PILOT PLANTS
- TECHNOLOGY SERVICES
- RELEVANCE ?

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TECHNOLOGY (IP)…

HIGH LEVEL, QUALITY KNOWLEDGE (S)

↓

KNOWLEDGE, PUBLICATIONS AND PhDs

↓

INTELLECTUAL PROPERTY-IP (T)

???...

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IPR…

HIGH LEVEL, QUALITY KNOWLEDGE (S)

↓

KNOWLEDGE, PUBLICATIONS AND PhDs

↓

INTELLECTUAL PROPERTY-IP (T)

INDUSTRIAL PROPERTY | COPIABLE PROPERTY

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IPR…

HIGH LEVEL, QUALITY KNOWLEDGE (S)

↓

KNOWLEDGE, PUBLICATIONS AND PhDs

↓

INTELLECTUAL PROPERTY-IP (T)

INDUSTRIAL PROPERTY   COPIABLE PROPERTY

MUST BE PROTECTED

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IPR…

HIGH LEVEL, QUALITY KNOWLEDGE (S)

↓

KNOWLEDGE, PUBLICATIONS AND PhDs

↓

INTELLECTUAL PROPERTY-IP (T)

INDUSTRIAL PROPERTY   COPIABLE PROPERTY

LEGAL OWNERSHIP (R)   (IPR)

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IPR

1. INDUSTRIAL PROPERTY RIGHTS

- PATENTS PAT.#
- TRADE MARKS ™
- INDUSTRIAL DESIGN ®
- TRADE SECRETS
- HIGH LEVEL KNOW HOW
  - TECHNICAL SKILLS
  - MANAGERIAL SKILLS
- etc

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IPR…

2. COPYRIGHTS ©

- CREATIVE EXPRESSION
- LITERARY
- MUSIC
- SOFTWARE
- DATABASES
- PLANT VARIETIES
- GEOGRAPHICAL INDICATORS
- TRADITIONAL KNOWLEDGE
- LAYOUT DESIGN
- etc

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IPR…

HIGH LEVEL, QUALITY KNOWLEDGE (S)

KNOWLEDGE, PUBLICATIONS AND PhDs

INTELLECTUAL PROPERTY-IP (T)

INDUSTRIAL PROPERTY

COPIABLE PROPERTY

LEGAL OWNERSHIP (R)

(IPR)

LIABILITIES

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IPR…

HIGH LEVEL, QUALITY KNOWLEDGE (S)

KNOWLEDGE, PUBLICATIONS AND PhDs

INTELLECTUAL PROPERTY-IP (T)

INDUSTRIAL PROPERTY

COPIABLE PROPERTY

LEGAL OWNERSHIP (R)

(IPR)

LIABILITIES

ASSETS (TT)

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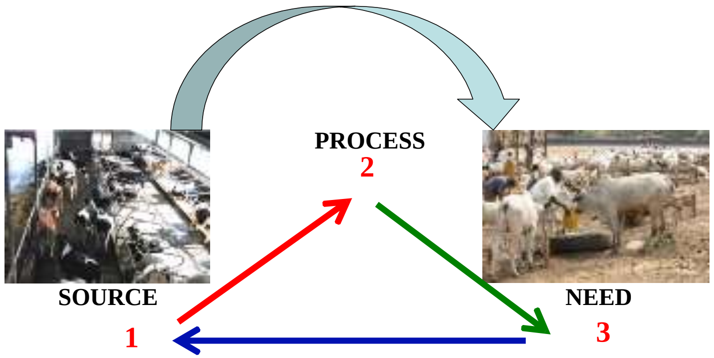
TECHNOLOGY (IP) TRANSFER (Skill)



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TECHNOLOGY TRANSFER PLATFORMS??

- SELF ACTUALISE
- OUTRIGHT SALE
- LICENSING
- JOINT VENTURE
- FRANCHISE (BUSINESS)
- GIFT/HELP
- etc etc

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INNOVATION & ENTREPRENEURSHIP

SOLUTIONS AND PRODUCTS

INNOVATION

OUTCOMES OF "DYNAMIC" DEPLOYMENT OF KNOWLEDGE, SKILLS AND KNOWHOW TO APPLY SOLUTIONS, REEL OUT PRODUCTS & SERVICES AND COMPETITIVELY SUSTAIN SOCIO-ECONOMIC DEVELOPMENT

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INNOVATION & ENTREPRENEURSHIP

ENTREPRENEURSHIP

Creative skills and trait of using proven and tested solutions to provide & move goods and services efficiently for very clear benefits

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INNOVATION & ENTREPRENEURSHIP (I)

- **EVERYBODY….. ARTISANS**
- **FEASIBILITY, FINANCING, TRAINING**
- **IP MANAGEMENT & LICENSING**
- **BUSINESS PLANNING/MANAGEMENT**
- **PRODUCTION, MARKETING, BRANDING….**

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ENTREPRENEURSHIP & INNOVATION (I)

- **PRODUCTS**
- **PROCESSES**
- **KNOW-HOW SERVICES (Consultancy etc)**
- **INDUSTRIAL SKILLS**
- **MANAGERIAL SKILLS**

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Trade marks:
- Made by "Nokia"
- Product "N95"
- Software "Symbian", "Java"

Patents:
- Data-processing methods
- Semiconductor circuits
- Chemical compounds

Copyrights:
- Software code
- Instruction manual
- Ringtone

Trade secrets:
?

Industrial Designs (some of them registered):
- Form of overall phone
- Arrangement of buttons in oval shape
- Three-dimensional wave form of buttons

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THE NIGERIAN PRACTICALS
(what & where !?)

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CURRENT NIGERIAN NATIONAL DEVELOPMENT & INDUSTRIALISATION STRATEGY/POLICY

"THE RENEWED HOPE AGENDA"
- SECURITY
- ECONOMY
- JOB CREATION
- AGRICULTURE and
- INFRASTRUCTURE

PRESIDENT BAT, 12TH JUNE 2023

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THE NIGERIAN STI CONTENT

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STI INFRASTRUCTURE (SUPPLY)

- Over 250 Universities
- Over 600 NBTE Accredited (~140 Polytechnics)
- Nearly 100 COE
- Over 300 Research Institutions/Centres
- Many Research capabilities (Labs, Workshops, Libraries)
- Many World-Class Foreign Industries
- Large pool of high class capacities (Professors, PhDs, Professional bodies, Diaspora capacity)
- LARGE NUMBER OF OTHER NETWORKS

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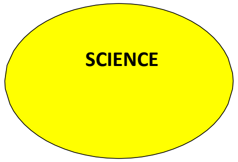
RESEARCH FACILITIES & OUTPUT

FACTS AND FIGURES (Research)



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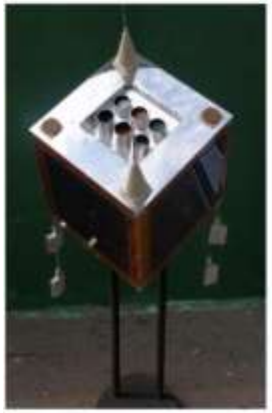
SPACE TECHNOLOGY



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Temporary Bioreactor Immersion Systems

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RENEWABLE ENERGY RESEARCH

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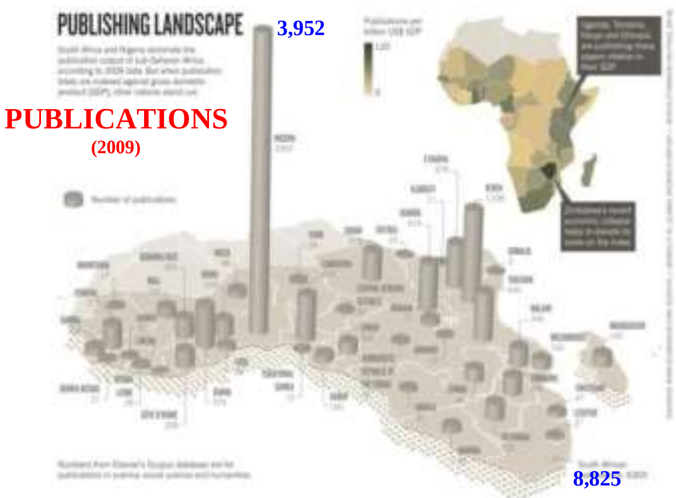

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DEVELOPMENT “POTENTIAL” (T)

POSSIBILITIES AND APPLICATIONS (Development)

ENGINEERING & TECHNOLOGY

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US PATENT NO:5,800,819 (1998)


United States Patent [19]
Wambebe et al.

[11] **Patent Number:** **5,800,819**
[45] **Date of Patent:** **Sep. 1, 1998**

[54] *PIPER GUINEENSE, PTEROCARPUS OSUN, EUGENIA CARYOPHYLLATA,* AND *SORGHUM BICOLOR* EXTRACTS FOR TREATING SICKLE CELL DISEASE

[75] Inventors: **Charles Wambebe**, Abuja; **P. O. Ogunyale**, Oyo; **K. S. Gamaniel**, Abuja; **R. N. Nasipuri**, Abuja; **J. I. Okogun**, Abuja; **Babatunde Samuel**, Abuja; **Akin Olusola**, Abuja; **Abayomi Orisadipe**, Abuja, all of Nigeria

[73] Assignee: **National Institute for Pharmaceutical Research and Development Federal Ministry of Science and Technology**, Abuja, Nigeria

[21] Appl. No.: **786,313**

[22] Filed: **Jan. 21, 1997**

[30] **Foreign Application Priority Data**

Jan. 25, 1996 [NG] Nigeria RP12360

[51] **Int. Cl.**[6] **A61K 35/78**
[52] **U.S. Cl.** **424/195.1**; 514/814; 514/815
[58] **Field of Search** 424/195.1; 514/814, 514/815

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,473,550 9/1984 Robinson 424/195.1
5,225,447 7/1993 Weinheimer 514/549
5,447,720 9/1995 Fahda 424/195.1
5,449,516 9/1995 De Araujo 424/195.1

OTHER PUBLICATIONS

Houston, Amer. J. Clin. Nutr., 26:1261–1264, 1973.

Primary Examiner—David M. Naff
Assistant Examiner—Janet M. Kerr
Attorney, Agent, or Firm—Shook, Hardy & Bacon L.L.P.

[57] **ABSTRACT**

A phytochemical composition for treating sickle cell disease is provided. The composition is a cold water extraction product of a mixture containing *Piper guineenses* seeds, *Pterocarpus osun* stem, *Eugenia caryophyllum* fruit, *Sorghum bicolor* leaves and potash. Also described are mixtures of phytomaterials used for preparing the extraction product, methods for making the extraction product, and methods for using the extraction product.

13 Claims, No Drawings

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INNOVATION "OPPORTUNITIES" (I)

SOLUTIONS AND PRODUCTS

INNOVATION

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SCIENCE KITS

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LEATHER PRODUCTS

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NUMEROUS INVENTIONS/INNOVATIONS

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<u>NIGERIA's</u>

SCIENCE TECHNOLOGY & INNOVATION BANDWIDTH

- **HIGH**
- **INTERMEDIATE**
- **LOW**
- **TRADITIONAL/LOCAL**
- **ENTREPRENEURSHIP**

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DESPITE ALL THESE OUTPUTS, CREATIVITIES & INNOVATIONS ON THE GROUND……

<u>THE REALITIES (rural life 70%)</u>

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• >70% OF THE POPULATION

(NEARLY 150 MILLION)

SUB-URBAN/RURAL LIFE DOMINATES

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BASIC EDUCATION

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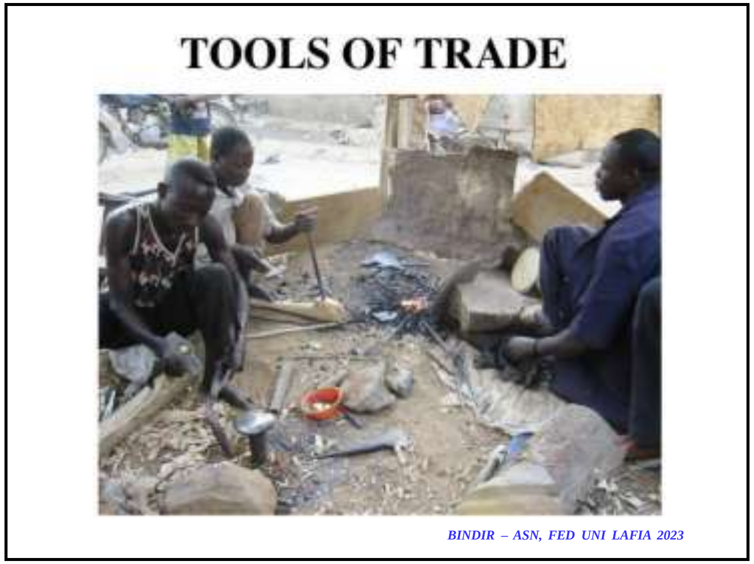

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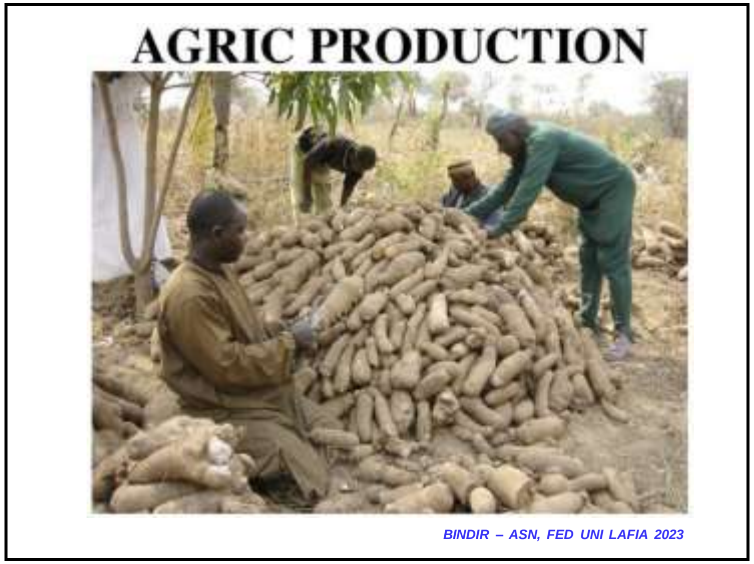

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Cottages & SMEs

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THE LIST IS LONG!!!

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A CLEAR EVIDENCE OF
STI AND SOCIO-ECONOMIC DEVELOPMENT
DISCONNECTION IN OUR COUNTRY

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THE FUNDAMENTAL
“HIDDEN” CHALLENGE

(PRACTICALLY!!)

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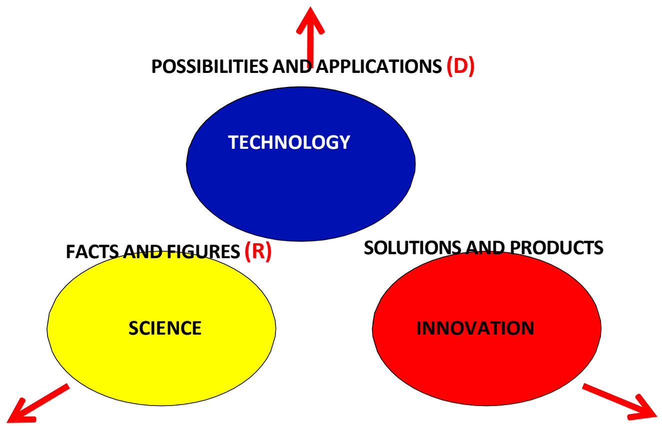
REALITIES OF STI POSTURE?



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REALITIES OF STI POSTURE?

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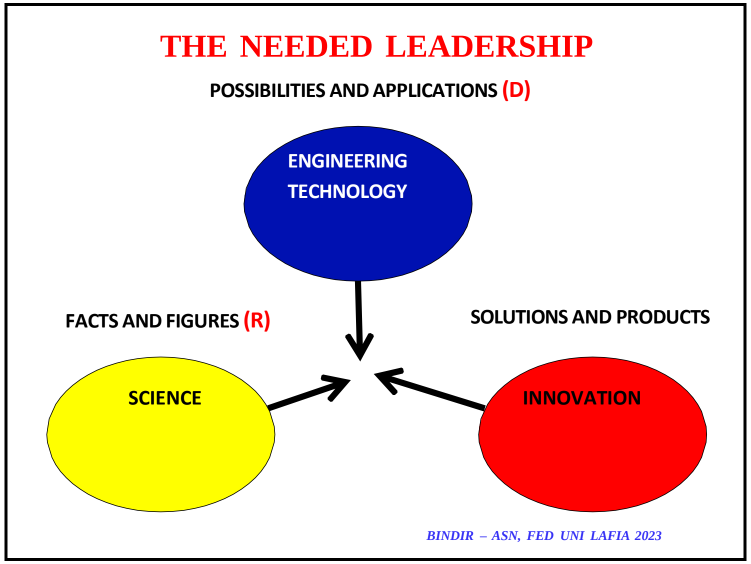

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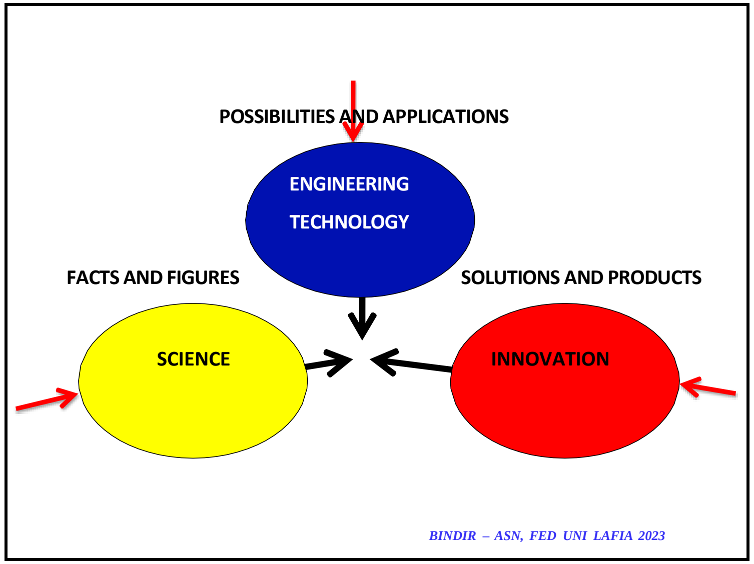

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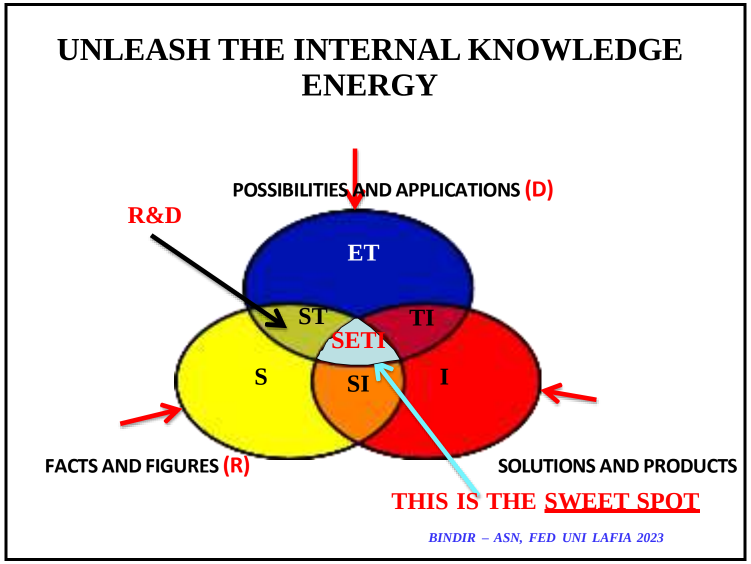

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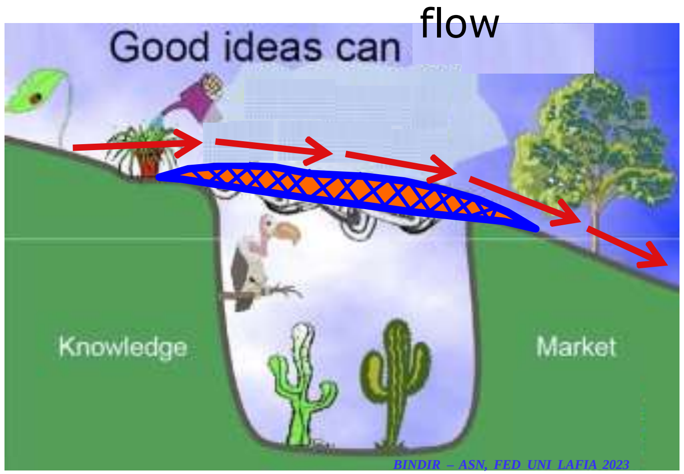
VIABLE LEADERSHIP & INNOVATION!



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MORE SPECIFICALLY….

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LITERAL SHOCK-TREATMENT STRATEGY TO EVOLVE A CONNECTED STI SYSTEM…

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TERTIARY INSTITUTION SYSTEM

- **TRAINING CENTRES/SCHOOLING**
- **R&D AND EXPERIMENTATION CENTRES**
- **PRODUCTION AND INDUSTRIAL CENTRES**
- **ENTERPRISES WHO NEEDS TO SELL THEIR PRODUCTS TO SURVIVE**
- **COLLABORATORS NATIONALLY AND INTERNATIONALLY**

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HIGH SKILLS & KNOW-HOW

HUMAN CAPITAL

- **INNOVATIVE ENTREPRENEURS/LEADERS**
- **HIGH VALUES**
- **KNOW - HOWS**
- **MANAGERIAL SKILLS**
- **ORGANISATIONAL SKILLS**

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COMPARATIVE ADVANTAGE

RECOGNISE ENVIRONMENTAL CAPITAL

- **THE VALUE AND POTENTIAL OF THE NATURAL ENVIRONMENT (OPPORTUNITIES)**
- **THE SUN, CLIMATE, RIVERS, SEEDS, INSECTS, ANIMALS, MICROBES, etc**
- **ORGANISE TO PRODUCE, PROCESS, COMMERCIALISE EFFECTIVELY**
- **LITERALLY TO CREATE & APPLY VIABLE SOLUTIONS FOR DEVELOPMENT**

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SOCIAL CAPITAL

SOCIO-CULTURAL/INTERPERSONAL CAPITAL

- **TO NETWORK AND CREATE STRONG CONNECTIONS**
- **TO SHARE KNOWLEDGE, EXPERIENCES, DIFFICULTIES, OPPORTUNITIES**
- **TO NEGOTIATE, DISCUSS AND WORK JOINTLY**

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EFFICIENCY

TECHNICAL CAPITAL

- **TO INVESTIGATE, DISCOVER, DEVELOP, INCORPORATE AND INTEGRATE INNOVATIVE TECHNOLOGIES**
- **USE NEW TOOLS, NEW MACHINES, NEW PROCESSES, PRODUCTION TECHNIQUES**
- **ALL TOWARDS IMPROVEMENT OF PRODUCTIVITY (DEVELOPMENT)**

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FINANCES

FINANCIAL CAPITAL

- TO BETTER MANAGE FINANCES
- TO START, COMPLETE & SUSTAIN PROJECTS
- etc

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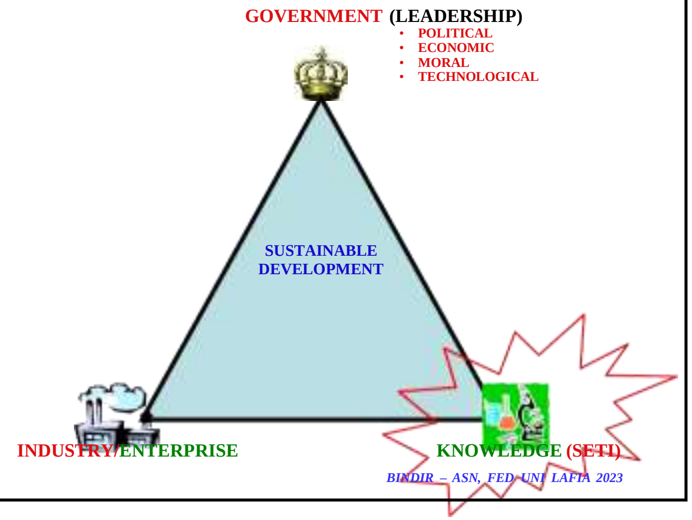
HELIX OF SUSTAINABLE DEVELOPMENT



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THIS IS POSSIBLE!

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BUT WE MUST ENSURE THAT !!!

- ITS NO BUSINESS AS USUAL
- MATCH WORDS WITH ACTIONS
- LEAD AND FOLLOW WELL
- BE SYSTEMATIC & STRATEGIC
- REFLECT AND IMPROVE
- etc

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CONCLUSIONS

&

RECOMENDATIONS

RECOMMENDATION (1)

INTENSE/PROUD PROMOTION OF QUALITY NIGERIA'S TECHNOLOGY OUTPUTS:

PROPER & STANDARD NATIONAL EXHIBITIONS & TECHMARTS

RECOMMENDATION (2)

DEVELOP STRATEGIC, VIABLE AND VISIBLE *PARTNERSHIPs THAT ENGENDERS CREATIVITY AND INNOVATION DIFFUSION*

RECOMMENDATION (3)

BUILDING THE CRITICAL MASS OF "CREATIVE & INNOVATIVE" MANPOWER STRATEGICALLY

(FOREIGN TECHNOLOGY TRANSFER, ADAPTATION AND DOMESTICATION)

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Engage Matured Technocrats & Research Fellows on Mega Technology public/private projects for

Quick Learning and Diffusion

155

RECOMMENDATION (4)

IASP

THINKING OUT OF THE BOX

TO LINK ACADEMIA TO SOCIO-ECONOMIC DEVELOPMENT

WAITRO

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ESTABLISH & MANAGE CREATIVITY & INNOVATION INFRASTRUCTURE:

"SCIENCE AND TECHNOLOGY PARKS"

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RECOMMENDATION (5)

SYNERGISED IMPLEMENTATION OF THE "NEW" STI POLICY

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(A)

ESTABLISH AND TAKE ADVANTAGE OF THE APPROVED NATIONAL RESEARCH AND DEVELOPMENT FUND (NRDF) "minimum of 1% GDP"?

CENTRALISE R&D FUNDS!!

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(B)

FULLY FUNCTIONALISE THE APPROVED & INAUGURATED NRDI COUNCIL

(CHAIRED BY THE PRESIDENT)

COORDINATE KNOWLEDGE GOVERNANCE AT THE TOP

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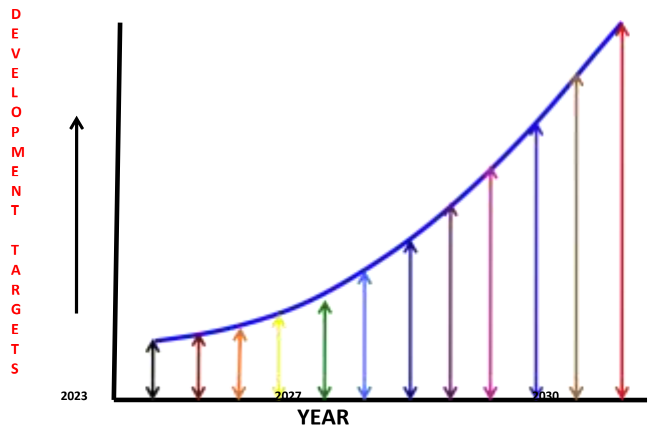
MEASURED VISION-LETS…



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WITH ALL THESE, I HOPE…

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ALL
HANDS
ON-DECK

I HAVE BRIEFLY DISCUSSED ISSUES ON:

STRENGTHENING AGRICULTURE FOR FOOD AND NUTRITION SECURITY, MARKET DEVELOPMENT AND EXPORT IN A CLIMATE CHANGE ENVIRONMENT IN NIGERIA

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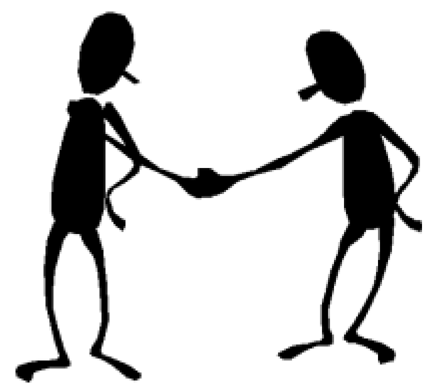

THANK YOU

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LEAD PAPER 2

Dr. Ibitoye Oyewale *FCA, ACIT*

Necessity For Resilience & Nutrient-Dense Improved Quality Crop Varieties: *Strength For Market Development, Export, Reduction of Farmers Vulnerability and Food Security.*

By

Dr. Ibitoye Oyewale
MD/CEO Premier Seed Nigeria Limited

A paper presented at the 57th Annual Conference of the Agricultural Society of Nigeria held at Federal University of Lafia, Nasarawa Sate.
24th October, 2023

ABOUT PREMIER SEEDS

Premier Seeds is a leading agricultural seed company in Nigeria with focus on production and marketing of certified seeds of improved crop varieties to farmers in Nigeria and across the West African sub-region

Seeding Nigeria to feed the Nation

In business since 1994 in Nigeria

Scaled to Ghana and Benin Republic in 2022

28 Zonal offices across the Nation and large agro-dealer networks well as last mile seed delivery system

- Agriculture is the most vulnerable sector to climate change, owing to its huge size and sensitivity to weather parameters, thereby causing huge economic impacts. The changes in climatic events such as temperature and rainfall significantly affect the yield of crops.
- Several mitigation measures such as regenerative agricultural practices need to be considered in order to reduce the effects of climate change on farmers productivity.

6 Core Principles of
REGENERATIVE AGRICULTURE

Effects of climate change on farmers productivity

- The effects of climate change such as temperature increases, irregular and variable rainfall patterns, flooding of riverbanks, drought and desertification, more frequent extreme weather events, and loss of biodiversity affects the productivity of smallholder farms.

- As far back as 2012, the country was already suffering from variability in the climate and high-intensity rainfall events in the central and southern regions, which led to perennial flood disaster with total losses and damages of about USD 16.9 billion.

- Unless urgent measures are taken to address these challenges, Nigeria's food security and by extension the economy is at great risk.

Micronutrient Deficiency

- More than 2 billion people worldwide do not get enough essential micronutrients in their diets to properly sustain health.

- Micronutrient deficiencies lead to negative nutritional and health outcomes, including increased susceptibility to infectious diseases, poor physical growth, and diminished cognitive development.

- They also result in significant losses due to decreased productivity and economic potential later in life.

- Several development partners lead the development and delivery of biofortified crops to improve micronutrient intake and the health status of millions of people living in low-income smallholder farm households globally.

- **Vitamins:** 29% of children under five years old in Nigeria are deficient in vitamins A which impairs growth, causes eye damage leading to blindness, and increases the risk of infection such as diarrrhea diseases.

- **Zinc:** 47% of pregnant women and 20% of children under five are deficient in zinc, which contributes to stuntiingand a loss of appetite, llowers immunity and increases the risk of diarrhea diseases and respiratoet infection

- **Iron:** Report show that 76.1% of pre-school age children and 66.7% of pregnant women suffer from anemia, oftencaused by iron deficiency, which affects mental development and learning capacityincreasesweakness and fatigueand may increase the risk of women dying in childbirth.

- One major breakthrough over the years was the support to develop, register, release and commercialize improved seeds of various nutrient dense crop varieties.

Climate-smart solutions

- Climate-smart agriculture is an approach to guide actions to transform and reorient agricultural systems to effectively and sustainably support development and food security under a changing climate (FAO).

- The climate smart agriculture (CSA) concept reflects an ambition to improve the integration of agriculture development and climate responsiveness. It aims to achieve food security and broader development goals under a changing climate and increasing food demand.

- PSNL supports smallholder farmers to increase crop productivity and farm output through several affordable options made available to farmers across the nation depending on their specific needs.

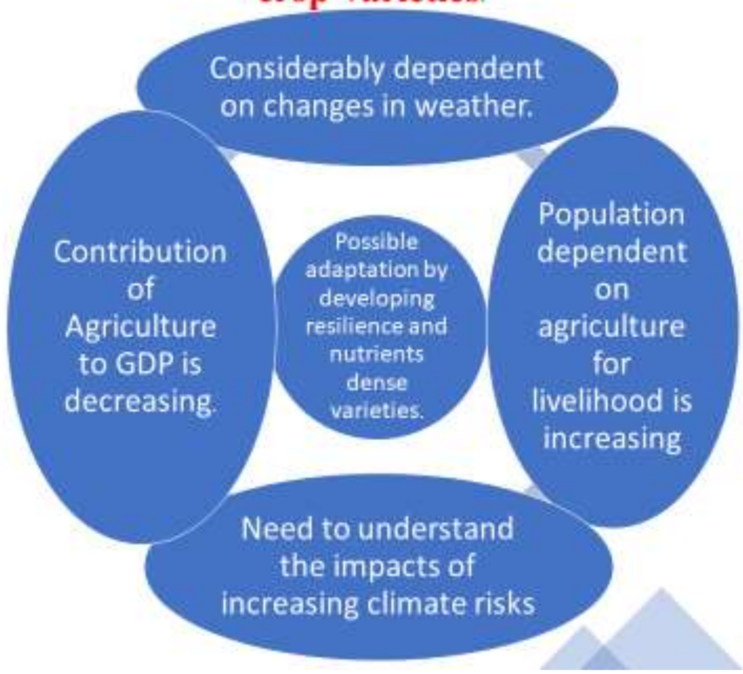
Concept of resilience of improved crop varieties

- These refers to crops that have been bred or developed to be more resistant to environmental stressors, such as drought, pests, or disease.

- These crops may also have improved nutritional value or other qualities that make them more attractive to consumers.

- It is a relatively new approach to developing the variety that will promote technical, political and financial condition for the achievement of sustainable developments goal.

Nigeria agriculture and necessity for resilience and nutrient dense crop varieties.



Roles of the public and private sector in promoting resilient and nutrient dense crop varieties.

Roles of Private sectors.

- Development of new nutrient dense varieties that better adapted to climate change.
- Commercialization
- Protection of the intellectual property while making their product available to the public.

Roles of Public sector

- Breeding and development of nutrient dense varieties that better adapted to climate change.
- Collaboration with private partners for commercialization.
- Protection of the intellectual property while collaboration with private partners for commercialization

Supplier of innovative goods and services:

✓The private sector has an enormous role in providing solutions to climate change.

✓There is a clear need to meet the adaptation priorities with expertise to technology and service delivery.

Adaptation through innovative, technology and design of resilient infrastructure:

✓The private sector has competencies which can make a unique contribution to adaptation through innovative technology, design of resilient infrastructure, development and implementation of improved information system and the management of major project.

Scaling up or leveraging public sector capital:

✓Private sector should be seen battle against climate change not as a burden but rather the major economic opportunity of our generation.

✓The greater involvement of private sector is critical, if any region is to prepare itself for both the challenges and opportunity rather than rely on public sector.

Potential benefits for seed companies involving in development and commercialization of resilient and nutrient dense varieties

Competitive advantage → If a company is know for developing high quality, resilient crops and nutrient dense crop varieties, it could gain a competitive advantage.

Creation of tied products → A company could develop a crop variety that work best with a particular fertilizers or herbicides that is also sell.

Development of crops to a specific need of the society → A company could develop a crop variety that is especially well suited for a particular climate and society.

Resilience and Nutrition Dense Improved Seed Varieties are crucial for several reasons, Including the following

- Enhancement of food security.
- Boosting export Potential
- Reduction of farmers' vulnerability.
- Market development.
- Export growth

Significance of Resilience and Nutrition Dense Improved Seed Varieties

Enhancement of food security.

These varieties are bred to possess specific traits such as disease resistance, high yield potential, and adapitality to varying environmental condition, by cultivating these improved seeds, farmers can ensure a more reliable and abundant food supply, thereby strengthening food security at both local and global level

Reduction of farmers' vulnerability

.

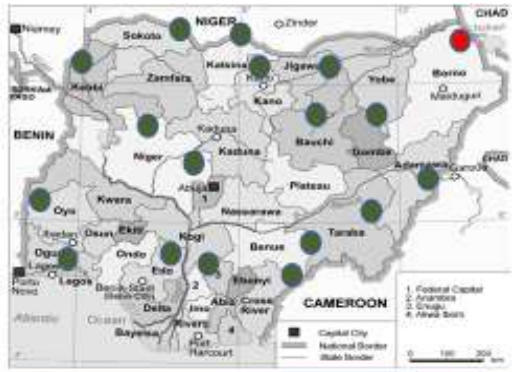
The traditional seeds often lack resilence against pests, diseases , and climate change adaptitlity. By Using improved seeds that posses resistance traits, farmers can minimize crop losses, thereby reducing the financial burden caused bycrop failure, Furthermore, these varieties often have higher yields, enabling farmers to generate more incomes and improved their livelihoods.

Market development and Export growth

They can be developed to meet market demand for specific quality attribute and traits, such as colour, taste, or shelf life , maturity period . By producing and exporting crops from improved seeds , country can capitalize on their unique agricultural strengths, increase their competitiveness in the global market and boosting economy.

Challenges to adoption of resilient and nutrient dense crop varieties

- ✓ Lack of awareness about resilient crop varieties
- ✓ Lack of access due to infrastructure or resources
- ✓ Farmers may be skeptical of new varieties
- ✓ Some of the crops might not be affordable in term of price



Ways to address these challenges

- ✓ Creation of awareness through campaigns and training programs,
- ✓ Framer to farmer exchange can help to overcome the lack of awareness
- ✓ Availability of seed in the open market
- ✓ Subsidies the price of seeds by Government.

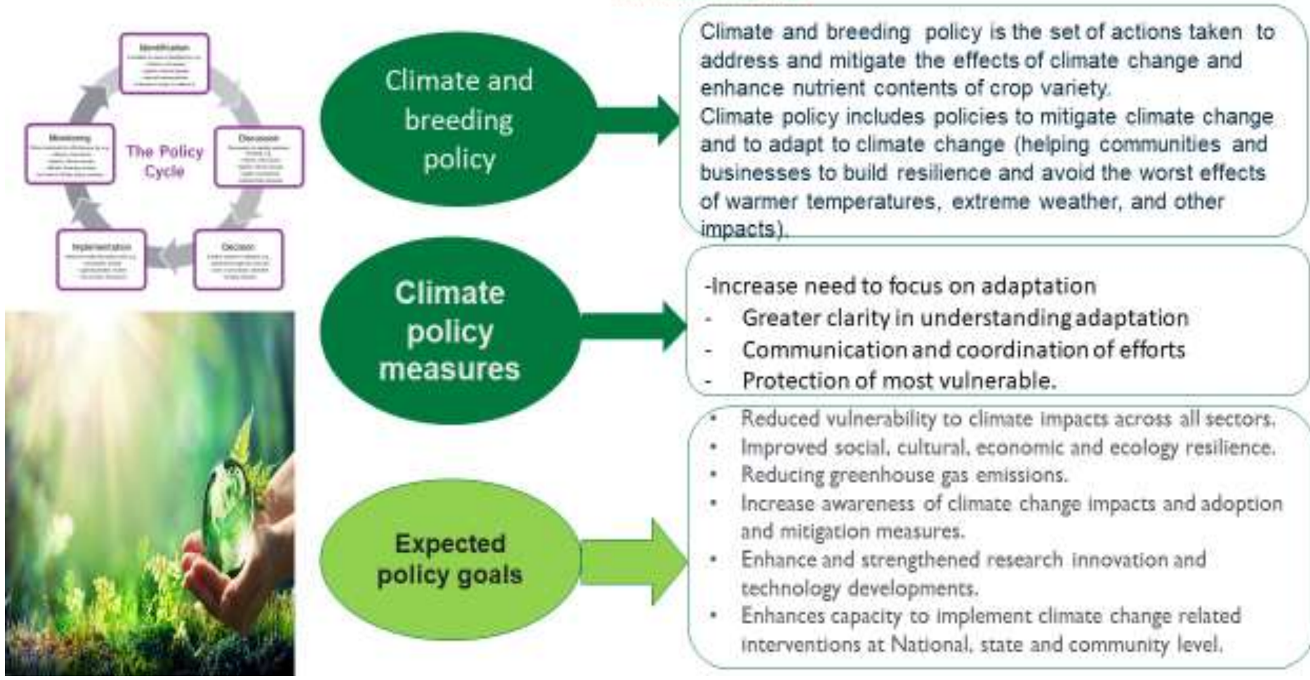
Investment models to enhance resilience and nutrition dense crop varieties

Climate resilience investment model → Climate resilience investment models aims to create a more resilient global financial industry in which key incentive structures foster an accurate pricing of physical climate risks in investment decision-making, resulting in more resilient economies and communities across the world

Pillars of resilient/ nutrient dense investment model → This models consists of five pillars: threshold capacity, coping capacity, recovery capacity, adaptive capacity, and transformative capacity

strategies for resilient & nutrient dense investment model → Strategies for Climate resilience investment is the ability to anticipate, prepare for, and respond to hazardous events, trends, or disturbances related to climate. Improving climate resilience involves how climate change will create new, or alter current, climate-related risks, and taking steps to better cope with these risks in the investment.

Policy frameworks and regulatory measures to incentivize climate resilience investments



Economics & policy innovation for resilient and nutrition dense crop varieties

- Identifying synergies and align food security, adaptation, market development and mitigation that may arise in transforming.
- Identifies the local institutions needed to support the breeding and development of resilient and nutrition dense varieties.
- Provide assistance for strategic planning that integrates resilient and nutrition dense varieties, agricultural development, food security, market development, policy and objectives.
- Builds mechanisms and investment plans to combine resilient and nutrition dense crop varieties finance with agricultural investments finance to support the innovation.
- Make agriculture productive, sustainable, remunerative and climate resilient.

How can Policy Enable Scaling Integrated Solution

Some key questions to get us started:

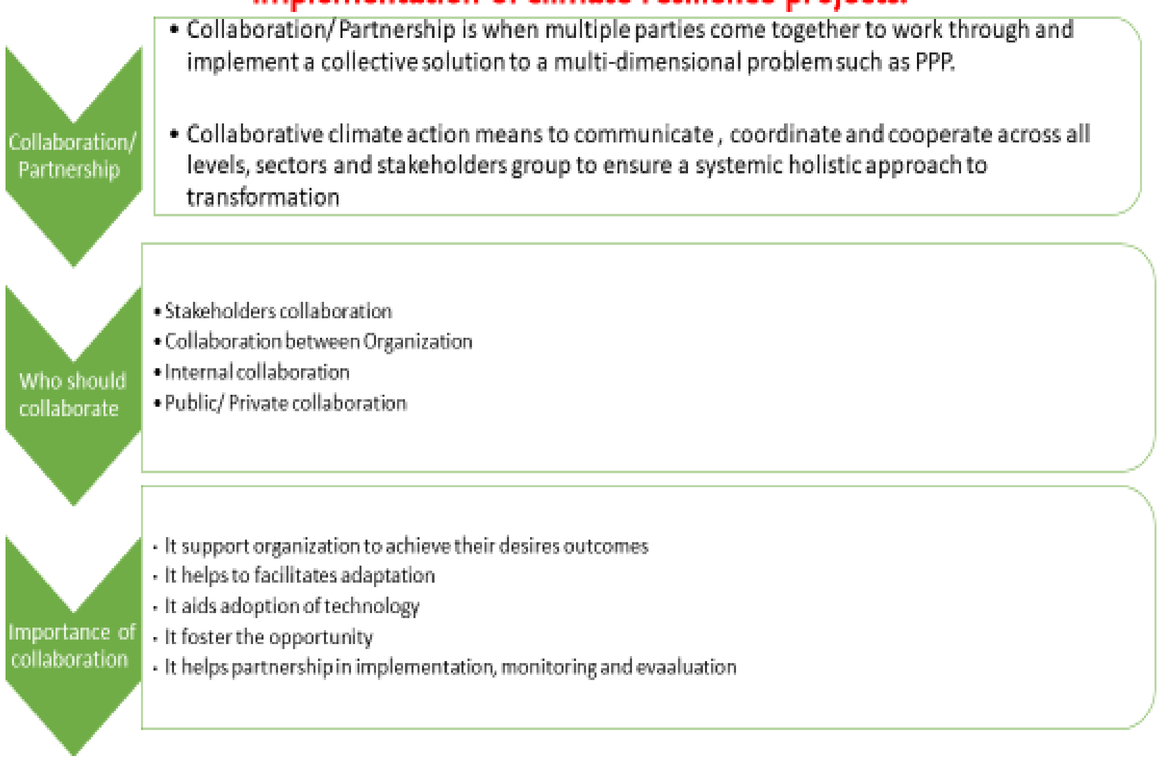
National Agriculture Technology and Innovation Policy (NATIP) – 2022 – 2027 - has laid strong foundations for enabling reforms in both climate and nutrition smart agriculture. How can the key relevant elements of NATIP be catalyzed and implemented?

Reduced emissions and promoting carbon sinks not always easy because markets default to choices that often work for short term goals rather than long term sustainable development. How can environment policy play a role in supporting sustainable and nutritious agriculture and natural resource use behaviours through the National Climate Change Strategy?

What are the key institutional supports – e.g in R&D for National Agriculture Research Systems, for rapid varietal release and standards, early generation seed access, that can bring innovations in CSA and NSA to markets quickly and cost effectively?

Finally what policy and planning coordination mechanisms and roadmaps at both the federal and state level can help realize policy goals.

Fostering partnership and collaboration among stakeholders for effective implementation of climate resilience projects.



Conclusion

- The importance of resilient and nutrition-dense quality crop varieties cannot be overstated. Their multifaceted impact on market development, export competitiveness, reduction of farmers' vulnerability, and food security underscores their indispensable role in global agriculture.
- Governments, agricultural organizations, Research institute, seed companies and communities must collaborate to promote the cultivation and consumption of these crops. By investing in research, technology, and education, Nigeria can create a resilient agricultural sector capable of addressing the challenges of the 21st century, ultimately leading to a healthier, more secure, and prosperous world.
- The necessity of improved seed varieties lies in their ability to strengthen food security by ensuring a more reliable food supply, boosting export potential by meeting market demands, and reducing farmers' vulnerability to risks. By embracing and promoting the use of these varieties, countries can create a more sustainable and prosperous agricultural sector.

LEAD PAPER 3

BIO-ECONOMY AND BIO-ENTREPRENEURSHIP: THE NEW PARADIGM IN AGRICULTURAL EDUCATION SYSTEM IN NIGERIA

Prof. Olumuyiwa James Jayeoba ***FSSSN, FHORTSON, RSS***

President, Association of Deans of Faculty of Agriculture in Nigerian Universities (ADAN)

Introduction

In Nigeria, the agricultural sector has long been the backbone of the economy, providing livelihoods for millions and contributing significantly to the nation's GDP. However, as global dynamics and the challenges of the 21st century continue to evolve, the need for innovation, sustainability, and entrepreneurship in agriculture has never been more pressing. This shift has given rise to a new paradigm in the agricultural education system, one centered on the bio-economy and bio-entrepreneurship.

The bio-economy represents a fundamental rethinking of our approach to agriculture, highlighting the sustainable utilization of biological resources, from crops and livestock to forestry and fisheries. In this context, bio-entrepreneurship emerges as a powerful force, igniting innovation and creativity in the agricultural sector, and equipping the next generation with the tools to transform challenges into opportunities. The Bio-Economy is a comprehensive framework that transcends traditional farming practices, encompassing the sustainable utilization of biological resources, innovative agricultural technologies, and the cultivation of bio-entrepreneurship. It seeks not only to enhance food security but also to create a resilient and diversified economy deeply rooted in agriculture. The confluence of traditional farming wisdom with cutting-edge biotechnology, renewable energy solutions, and value-added product development has given rise to an era where the boundaries of agriculture have expanded far beyond the fields.

This lecture delves into the transformation underway within the Nigerian agricultural education system. It will analyze the adoption of the Bio-Economy and Bio-Entrepreneurship as the driving forces propelling this sector towards innovation, sustainability, and economic prosperity. Through this lens, I will examine the evolving curricula, government initiatives, research endeavors, and the collaborative spirit of institutions both local and international. By understanding this new agricultural paradigm, we seek to shed light on the challenges, opportunities, and the promise it holds for Nigeria as it strives to meet the demands of a rapidly changing world and build a future that combines sustainable agricultural practices with entrepreneurial spirit.

Definition of Bio-Economy and Bio-Entrepreneurship

Bio-Economy:

The bio-economy is an economic system and framework that centers on the sustainable utilization of biological resources and processes to produce goods, services, and energy. It encompasses a wide range of sectors, including agriculture, forestry, fisheries, biotechnology, and healthcare. The key characteristic of the bio-economy is its reliance on renewable biological resources and the efficient utilization of waste streams, aiming to promote environmental sustainability while fostering economic growth and societal well-being. In the context of Nigeria, the bio-economy holds the potential to revolutionize traditional agricultural practices and create value-added products and services, contributing to the nation's economic development.

Bio-Entrepreneurship:

Bio-entrepreneurship is a dynamic and innovative approach to business within the bio-economy. It involves the identification, development, and commercialization of entrepreneurial opportunities related to biological resources and processes. Bio-entrepreneurs use their creativity, scientific knowledge, and business acumen to create sustainable ventures that address societal challenges, enhance resource efficiency, and generate economic value. In the agricultural context, bio-entrepreneurs may focus on areas such as agribusiness, biotechnology, sustainable farming practices, and the development of bio-based products. Bio-entrepreneurship plays a pivotal role in transforming traditional agricultural systems into more productive, environmentally friendly, and economically viable models, contributing to food security and rural development in Nigeria.

Significance of Agricultural Education in Nigeria

Agricultural education has a rich historical significance in Nigeria. It has been an integral part of the nation's educational landscape for decades, reflecting the country's strong agrarian tradition. Historically, many communities in Nigeria have relied on agriculture for sustenance and livelihoods, making it a fundamental aspect of the nation's heritage. Agricultural education is crucial in Nigeria due to the sector's economic significance. Agriculture has been a major contributor to the country's Gross Domestic Product (GDP) and provides employment to a significant portion of the population, especially in rural areas. Therefore, educating and training individuals in modern agricultural practices is vital for sustaining and enhancing the sector's contributions to the national economy.

Nigeria faces food security challenges, including insufficient food production, post-harvest losses, and inadequate access to nutritious food. Agricultural education plays a pivotal role in addressing these issues by equipping farmers and agricultural professionals with the knowledge and skills needed to improve food production, reduce losses, and enhance nutritional outcomes for the population.

Agriculture is a key driver of poverty reduction in Nigeria. By educating individuals in agricultural practices, entrepreneurship, and value chain development, agricultural education empowers people to engage in productive agricultural activities, increase their income, and escape the cycle of poverty. This aligns with Nigeria's broader development goals of poverty alleviation and economic empowerment.

The agricultural sector is evolving rapidly with advancements in technology and innovation. Agricultural education serves as a vehicle for introducing farmers and agribusiness professionals to modern, sustainable farming practices, cutting-edge technologies, and efficient resource management techniques. This helps increase agricultural productivity and competitiveness. Sustainable agriculture is critical for preserving Nigeria's natural resources, such as soil and water. Agricultural education promotes environmentally friendly farming practices, conservation methods, and the responsible use of resources. It helps mitigate the negative environmental impacts of agriculture while ensuring long-term sustainability.

Agriculture is the backbone of many rural communities in Nigeria. Agricultural education contributes to rural development by creating opportunities for rural youth, promoting entrepreneurship, and enhancing the overall well-being of rural populations. It encourages the development of agribusinesses and value chains, thereby reducing rural-urban migration.

The New Paradigm in Nigerian Agricultural Education

The evolving landscape of agriculture, characterized by the integration of bio-economy and bio-entrepreneurship, necessitates a new paradigm in agricultural education. To equip students and professionals with the skills and knowledge needed for success in this dynamic field, educational institutions must adapt and innovate. This new paradigm in agricultural education equips individuals with the skills, knowledge, and entrepreneurial mindset needed to thrive in the evolving bio-economy and bio-entrepreneurship landscape. It empowers the next generation of agricultural leaders to drive innovation, sustainability, and positive change in agriculture and related sectors.

The key components of this new paradigm in agricultural education are as follows:

a) ***Interdisciplinary Approach:***
Recognize the interconnectedness of agriculture with various sectors, including biotechnology, environmental science, business, and economics. Encourage interdisciplinary learning and collaboration to address complex agricultural challenges comprehensively.

b) ***Bio-Economy Integration:***
Incorporate bio-economy principles into the curriculum. Teach students about the sustainable utilization of biological resources, circular economy concepts, and the economic opportunities presented by the bio-economy.

c) ***Bio-Entrepreneurship Education:***
Offer courses and programs focused on bio-entrepreneurship. Equip students with the skills needed to identify opportunities, develop bio-based innovations, and navigate the challenges of starting and managing bio-entrepreneurial ventures.

d) ***Technology and Biotechnology Training:***
Emphasize training in cutting-edge technologies, including biotechnology, genomics, precision agriculture, and digital farming. Equip students with the ability to leverage these tools for sustainable agriculture and bio-based innovations.

e) ***Sustainability and Environmental Stewardship:***
Integrate sustainability principles into agricultural education. Teach students about sustainable farming practices, resource management, and environmental conservation, emphasizing responsible agriculture within the bio-economy.

f) ***Ethical Considerations:***
Include discussions on ethical considerations in biotechnology and bio-entrepreneurship. Foster an understanding of the ethical implications of genetic engineering, intellectual property rights, and responsible use of biological resources.

g) ***Experiential Learning:***
Promote experiential learning opportunities, such as internships, fieldwork, and research projects, to provide students with hands-on experience in agricultural settings and bio-entrepreneurial endeavors.

h) ***Innovation and Research Focus:***
Encourage a culture of innovation and research within educational institutions. Support faculty and students in conducting research projects that address real-world agricultural challenges and opportunities.

i) ***Global Perspective:***
Foster a global perspective by exposing students to international agricultural practices and global challenges. Encourage study abroad programs, partnerships with international institutions, and global research collaborations.

j) ***Entrepreneurship Incubators and Centers:***
Establish entrepreneurship incubators and centers within educational institutions to support students and alumni in launching bio-entrepreneurial ventures. Provide mentorship, access to funding, and resources for business development.

k) ***Continuous Learning and Adaptation:***

Emphasize the importance of continuous learning and adaptation within the rapidly evolving bio-economy. Encourage students and professionals to stay updated with emerging trends and technologies.

l) Partnerships with Industry:

Collaborate with industry partners to ensure that educational programs align with industry needs. Industry partnerships can provide students with real-world insights and opportunities for internships and employment.

m) Community Engagement:

Promote community engagement and outreach initiatives. Encourage students to work with local farmers and communities to address agricultural challenges and contribute to sustainable development.

n) Digital Learning and Online Resources:

Leverage digital learning platforms and online resources to make agricultural education more accessible and flexible for learners, including working professionals and remote students.

Role of Association of Deans of Faculty of Agriculture in Nigerian Universities (ADAN) in Developing Entrepreneurial Skills in Agricultural Students in Nigeria

Over the years, Association of Deans of the Faculty of Agriculture in Nigerian Universities (ADAN) played a crucial role in developing entrepreneurial skills in agricultural students in Nigeria. As a collective body representing academic leadership in agricultural education, ADAN can influence policies, curricula, and initiatives that promote entrepreneurship within the agricultural education system. Some key activities of ADAN in support of the development of entrepreneurial skills among agricultural students are as follows:

1. Establishment of Agribusiness Incubation Centers (AICs)

The Federal government of Nigeria through the Federal Ministry of Agriculture and Rural Development (FMARD) acting on the Memorandum of Understanding (MOU) between the Association of Deans of Agriculture in Nigerian Universities (ADAN) and Youth Initiative for Sustainable Agriculture (YISA) established Agribusiness Incubation Centers (AICs) in ten (11) Universities in Nigeria. The centers are designed to create successive generation of young agricultural entrepreneurs from the Faculties/Colleges of Agriculture in Nigeria Universities. The AICs will serve as the capacity-building component of the Agripreneurship Incubation & Mentorship (AIM) Programme. The AIM programme is anchor on five core pillars as listed

Pillar 1: Agribusiness Mindset Clinic (AMC)
Pillar 2: Incubation Model Farms (Imof)
Pillar 3: Agribusiness Incubation Lab (AIL)
Pillar 4: Young Agripreneurs Innovation Fund (YAI-Fund)
Pillar 5: Agribusiness Mentorship Platform (AMP)

The overall objective of the centers is to establish standard hands-on practical agribusiness training where the capacity of Agriculture students and community youths will be built on agricultural entrepreneurship skills to reduce practical agro-knowledge gap among Agriculture students and other youths so as to establish and run successful agro enterprises for job creation and food/social security.

The specific objectives is to create successive team of young Agribusiness Entrepreneurs to drive successful agricultural enterprises for national food and social security while creating jobs for other unemployed youths.

1. Training and capacity development of youths in agricultural entrepreneurship.
2. Providing trainings for innovative agribusiness start-ups and cooperatives.
3. Development of managerial skills and knowledge of the Nigerian agribusiness sector.

4. Creation and development of sustainable, globally competitive Agri-based SMEs that contribute towards the accelerated growth of the economy.
5. Creation and transfer of need-driven agricultural innovation.
6. Assist to create value added jobs and services by making individuals relevant in different areas of the agriculture value chain.
7. Create Awareness about Technology Incubation and Commercialization of Research and Development products and processes.
8. Foster an entrepreneurial culture, by providing the students, alumni, and faculty, opportunities to transform their business ideas to reality.

2. Strategic partnerships of ADAN and AFAN

Strategic partnerships between the Association of Deans of the Faculty of Agriculture in Nigerian Universities (ADAN) and the All Farmers Association of Nigeria (AFAN) have significant implications for students' bio-entrepreneurship in agriculture. These partnerships can create a supportive ecosystem that equips students with the skills, knowledge, resources, and real-world experience needed to become successful bio-entrepreneurs. Here are the implications for students:

i. ***Practical Exposure***: Students can gain practical exposure to the agricultural industry through internships, on-farm training, and industry visits facilitated by AFAN. This exposure helps them understand the challenges and opportunities in agriculture, a crucial foundation for bio-entrepreneurship.

ii. ***Mentorship and Guidance***: AFAN can provide experienced farmers and agribusiness owners as mentors to agricultural students. These mentors can offer guidance, share insights, and provide real-world perspectives on starting and managing agricultural businesses, including those based on bio-entrepreneurship.

iii. ***Access to Resources***: Students can access resources such as land, equipment, and financial support through AFAN's network. This is particularly valuable for students looking to launch bio-entrepreneurial ventures that may require physical resources.

iv. ***Networking Opportunities***: Joint events and networking opportunities between ADAN and AFAN bring students into contact with industry professionals, potential partners, and mentors. These connections are invaluable for students looking to launch or advance their bio-entrepreneurial endeavors.

v. ***Market Access***: AFAN's market knowledge and connections can help students navigate the complexities of selling agricultural products, including bio-based products. This support can be instrumental in the commercialization of student-led ventures.

vi. ***Collaborative Research***: Students can participate in collaborative research projects that address real-world agricultural challenges and opportunities. This practical research can form the basis for innovative bio-entrepreneurial ventures.

vii. ***Business Incubation***: Strategic partnerships can support the establishment of agricultural incubation centers where students can receive mentorship and practical support for launching and scaling their bio-entrepreneurial initiatives.

viii. ***Training and Capacity Building***: Students can benefit from joint training programs and workshops that equip them with essential skills in areas such as business planning, financial management, and sustainable agriculture practices, all of which are integral to bio-entrepreneurship.

ix. ***Access to Funding***: Collaboration with AFAN can provide students with information on funding opportunities, grants, and loans for starting and growing their bio-entrepreneurial projects. AFAN's expertise in this area can help students secure financial support.

x. ***Advocacy for Student Interests:*** ADAN and AFAN can work together to advocate for policies and initiatives that support the interests of student bio-entrepreneurs, including favorable regulatory frameworks, financial incentives, and educational programs.

xi. ***Youth Engagement***: Joint programs can focus on attracting and engaging young people in bio-entrepreneurship. This includes educational initiatives that foster entrepreneurial thinking and opportunities for students to participate in the agricultural value chain.

xii. ***Technology Transfer***: Students can gain access to advanced agricultural technologies, including biotechnology applications, through ADAN's collaboration with AFAN. This access allows them to explore innovative approaches to bio-entrepreneurship.

The strategic partnerships between ADAN and AFAN can empower agricultural students to become bio-entrepreneurs by providing them with practical experiences, mentorship, resources, market access, training, and networking opportunities. These collaborations can help students bridge the gap between academic knowledge and real-world application, fostering a new generation of bio-entrepreneurs who drive innovation and sustainability in the Nigerian agricultural sector.

3. Other activities of ADAN now or in the future for the development of entrepreneurial skills among agricultural students are as follows:

i. ***Curriculum Development***: ADAN works with faculties of Agriculture in Nigerian universities to enhance the curriculum of agricultural programs. This includes the incorporation of entrepreneurship courses, business management, and agribusiness training. The association advocates for a well-rounded education that not only emphasizes technical knowledge but also business acumen.

ii. ***Faculty Development***: ADAN organizes training and workshops for faculty members to equip them with the necessary skills and knowledge to teach entrepreneurship effectively. This includes best practices for engaging students in entrepreneurial activities and fostering innovation.

iii. ***Promotion of Entrepreneurial Culture***: ADAN actively promotes an entrepreneurial culture within agricultural faculties. This involves encouraging students to think creatively, take risks, and identify entrepreneurial opportunities in the agricultural sector. The association can also support entrepreneurial clubs and student organizations.

iv. ***Mentorship Programs***: ADAN can establish mentorship programs that connect agricultural students with experienced entrepreneurs and professionals in the industry. These mentors can provide guidance, share insights, and offer real-world perspectives on agribusiness.

v. ***Access to Funding and Resources***: The association can work to connect students with funding opportunities, grants, and resources for starting and scaling agricultural ventures. This may involve partnerships with financial institutions, government agencies, and private sector organizations.

vi. ***Internships and Practical Training***: ADAN can collaborate with industry partners to facilitate internships and practical training for students. This hands-on experience is invaluable in developing entrepreneurial skills and understanding the realities of agribusiness.

vii. ***Research and Innovation Support***: Encouraging research in areas of agribusiness and innovation is essential. ADAN can promote and fund research projects that focus on developing new agricultural products, technologies, and business models.

viii. ***Entrepreneurial Competitions***: Organizing entrepreneurial competitions and challenges within universities can foster a competitive spirit and encourage students to develop and pitch their agribusiness ideas.

ix. ***Advocacy and Policy Influence***: ADAN can advocate for policies that support entrepreneurship in agriculture at the institutional and government levels. This includes lobbying for favorable regulatory frameworks and incentives for young agribusiness entrepreneurs.

x. ***Networking and Collaborations***: The association can facilitate networking opportunities, both nationally and internationally, for students to connect with potential partners, investors, and customers.

xi. ***Information Dissemination***: ADAN can provide students with up-to-date information on market trends, technological advancements, and investment opportunities in the agricultural sector.

xii. ***Assessment and Evaluation***: Implementing mechanisms to assess and evaluate the impact of entrepreneurial programs and initiatives to ensure they are effective and beneficial to students.

ADAN, as an influential body within the Nigerian agricultural education system, has the potential to significantly impact the development of entrepreneurial skills among agricultural students. By promoting entrepreneurship and innovation, the association can help create a new generation of agribusiness leaders who contribute to the growth and sustainability of Nigeria's agricultural sector.

Conclusion

In conclusion, the emergence of the bio-economy and bio-entrepreneurship as a new paradigm in the agricultural education system in Nigeria marks a transformative era in the nation's pursuit of sustainable agriculture, economic prosperity, and global competitiveness. This paradigm shift represents a promising future where traditional farming practices harmoniously coexist with modern biotechnological innovations and entrepreneurial spirit. The implications of this new approach are vast and profound:

- ✓ Sustainability: Bio-economy emphasizes sustainable practices, leading to resource-efficient agriculture and the conservation of natural ecosystems. This commitment to sustainability ensures the long-term health of Nigeria's agricultural sector and the environment.
- ✓ Innovation: The integration of cutting-edge biotechnology, renewable energy solutions, and value-added product development fosters innovation in agriculture. This innovation is essential for addressing the challenges of food security, resource constraints, and climate change.
- ✓ Economic Growth: Bio-entrepreneurship, as a core component of this paradigm, provides opportunities for job creation, economic growth, and diversification. It encourages the development of small and medium-sized enterprises (SMEs) within the agricultural sector.
- ✓ Youth Engagement: The new paradigm attracts and engages young people in agriculture by presenting agribusiness as an attractive and profitable career option. It equips students with entrepreneurial skills, positioning them as future leaders in the agricultural industry.

- ✓ Global Competitiveness: Nigeria's participation in the global bio-economy market allows it to leverage its agricultural resources and expertise to compete on the international stage. The nation can emerge as a prominent player in the bio-economy, contributing to global food security and economic growth.
- ✓ Collaboration and Partnerships: The paradigm encourages collaboration between educational institutions, government bodies, international organizations, and industry stakeholders. This collaborative approach leverages diverse expertise and resources to propel Nigeria forward.
- ✓ Policy Reform: Bio-entrepreneurship and the bio-economy are reshaping policy landscapes in agriculture. Nigeria is working to create regulatory frameworks and incentives that support sustainable, innovative, and entrepreneurial practices in the sector.
- ✓ Value Addition: Bio-entrepreneurship encourages the development of value-added products from agricultural resources. This not only increases income for farmers and entrepreneurs but also adds value to Nigeria's agricultural exports.

As Nigeria navigates the dynamic landscape of the 21st century, the embrace of the bio-economy and bio-entrepreneurship represents a bold step towards realizing its agricultural potential. This paradigm transcends conventional farming, ushering in a future where agriculture is a beacon of sustainability, innovation, and economic empowerment. By nurturing a generation of bio-entrepreneurs, the agricultural education system becomes the bedrock of change, equipping students with the knowledge and skills needed to navigate the complexities of the modern agricultural sector.

In this journey, challenges remain, such as the need for increased investment, environmental concerns, and the fostering of a culture that values entrepreneurship. However, the promise and potential of the bio-economy are undeniable. It is an era of transformation where Nigeria's agricultural past converges with its future, forging a path that marries tradition with innovation, ethics with entrepreneurship, and sustainability with prosperity. The new paradigm is a testament to the resilience, adaptability, and forward-thinking spirit of Nigeria's agricultural sector and its commitment to a brighter, sustainable future.

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Corrigendum: Please note that the article on pages 864 - 866 has been corrected to bear the names and affiliations of the rightful owner of the article as shown on the paper now

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SUB-THEME 1

Establishment of Agricultural Fund: Framework and Implementation for Farm Financing and Management

ASSESSMENT OF ANCHOR BORROWER`S INTERVENTION PROGRAM (ABP) ON LIVELIHOOD OF SMALLHOLDER RICE FARMERS IN KEBBI STATE, NIGERIA

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ABSTRACT
The deficiency in authentic and ordered data concerning livelihoods makes it impossible to effectively support decision making for reducing poverty, enhancing food insecurity and sustaining living standard. This study seeks to assess the Anchor Borrower`s Program on livelihood of smallholder rice farmers in Kebbi State, Nigeria. Multistage and random sampling methods were used to select 397 each for beneficiary and non-beneficiary rice farmers giving a sample size of 794. Data collected was analyzed using Principal Component Analysis (PCA). The results reveal that the Asset Score Index of the poorest smallholder farmers is -0.0173 and the richest farmer is 0.526 with a total net asset score index of 0.061 for beneficiary rice farmers and -0.022 for non-beneficiary rice farmers. This suggests an improved livelihood of ABP beneficiary over the non-beneficiary thus, it is recommended that the program be sustained and be extended to more smallholder farmers in the State and country at large.
Keywords: *Anchor Borrowers' Program, Livelihood, Smallholder farmers, Beneficiaries, Non-beneficiaries.*

INTRODUCTION
Agriculture generates an average of 23.1million tons of food per day, offers livelihoods for about 2.5 billion individuals and the major source of income and jobs for poor, rural households (Convention on Biological Diversity, 2018). In spite of decades of attention given to; agricultural development, food security and rural poverty, poverty and food insecurity remain, especially amongst rural dwellers in Asia, Africa and Central America (Thornton *et al*., 2019)**.** Report has shown that in 2017, 3.4 billion inhabitants lived in rural areas, having most 15% and 79% of low and middle income countries for which many sourcing their income from small-scale agriculture (Lowder *et al*., 2019) and there are about 570 million farms out of which approximately 500 million are less than 2 ha thus, accounting for about 12% of the world's agricultural land.
Nigeria has a land area of 924, 000km^2, 3/4 of the land is good for farming, nevertheless, less than half of it has not been exploited to produce crops, because majority of the smallholder farmers are deficient in access to capital to purchase inputs such as improved seeds, fertilizers, agrochemicals and to buy or rent mechanized equipment and other services that may enhance their productivity and increase their incomes enough to be out of poverty (Aderemi, 2017). Thus, Anchor Borrowers Programmes (ABP) was introduced to create a linkage between large scale processors involved in both primary and secondary processing and the smallholder farmers (SHFs). The main driving force of the ABP is the provision of farm inputs in kind (i.e. farm equipment, fertilizer, seeds, agrochemicals etc.) and in cash for farm labor and extension services to smallholder farmers to stimulate agricultural production, stabilize inputs supply to agro processors and address the country's negative balance of payments on food crops (Inara Foundation, 2023). Therefore, gathering the needed, relevant and efficient information on livelihoods is very germane for facilitating evidence-based policy decisions. The lack of authentic and ordered data concerning different aspect of livelihoods makes it impossible to effectively and efficiently support decision making for reducing poverty, enhancing food insecurity and sustaining living standard. It is based on this idea that this study aims to assess the anchor borrower`s intervention program (ABP) on livelihood of smallholder rice farmers in Kebbi State Nigeria. Furthermore, little or nothing is known about the livelihood of beneficiaries' of ABP rice farmers in Kebbi State, hence there exists a clear knowledge gap that this current research attempts to bridge.

METHODOLOGY
Study Area
The study was conducted in Kebbi State which has a total projected population of approximately 4,738,267 people (National Population Commission, 2019). A GPS coordinate of between latitude $10^0\ 05^1$ N and $13^0\ 27^1$ N and longitude $3^0\ 35^1$ E and $6^0\ 03^1$. The State is bordered by Sokoto State, Niger State, Zamfara State, Republic of Niger and Benin Republic. It has a total area of 36,800 km² characterized by Sudan and Sahel-Savannah. The southern part is generally rocky with the Niger

River traversing the State from Benin Republic to Ngaski LGA. The northern part of the State is sandy with the Rima River passing through Argungu to Bagudo LGA where it empties into the Niger. State is tropically characterized by two season's i.e. rainy and dry seasons. The rainy season starts from April and ends in October with its peak period between July and August, while the dry season starts from November and last to February (harmatan period) with low temperature in the nights. The weather between March and June is hot with an average temperature between 38^0 and 43^0 c. Agriculture is the main occupation of the people especially in rural areas, crops produced are mainly grains in addition to animal rearing and fishing.

Sampling Procedure and Sample Size

A multistage sampling technique was used in the selection of sample size for the study. At stage I, Kebbi State was divided into four Agricultural zones (i.e. Argungu, Bunza, Yauri and Zuru zones), At stage II, two local governments areas were purposively selected based on the prevalence of ABP beneficiaries, given a total of eight (8) local government areas for the study. At stage III, a proportionate sampling of 0.08% (i.e. Argungu 58, Dandi 26, Shnga 37, Yauri 74, Birnin Kebbi 87, Bagudo 88, Sakaba 11 and Zuru 16) was employed to establish the sample size given a total sample size of 397 respondents from ABP beneficiaries and a corresponding number of non-beneficiaries.

Analytical Technique

Principal Component Analysis (PCA) was used to determine and Compare the level of improvement in livelihood of ABP beneficiary and Non beneficiary Rice Farmers using farmer's asset as proxy to income. The result of the asset index model derived from PCA for each household asset is specified by the following formula:

$$Y = \frac{x_1 - \bar{x}_1}{a_1(s_1)} + \frac{x_2 - \bar{x}_2}{a_2(s_2)} + \cdots + \frac{x_k - \bar{x}_k}{a_k(s_k)}$$

Where:

$\bar{x}_k$ and s_k are the mean and standard deviation of asset x_k and α represents the weight for each variable x_k for the first principal component. The first principal component variable across households has a mean of zero and a variance of λ, which corresponds to the largest eigenvalue of the correlation matrix of x. The first principal component Y yields a wealth index that assigns a larger weight to assets that vary the most across households so that an asset found in all households is given a weight of zero (McKenzie, 2003). The first principal component or wealth index can take positive or negative coefficient. PCA coefficients have a fairly intuitive interpretation. The coefficient on any one variable is a function of how much information it provides about the other variables. If ownership of one type of asset is highly indicative of ownership of other assets, then it receives a positive coefficient. If ownership of an asset contains almost no information about what other assets the household owns (its correlation coefficient is near zero), then it receives a coefficient near zero. And if ownership of an asset indicates that a household is not likely to own few other assets, then it receives a negative coefficient. Higher and lower coefficients mean that ownership of that asset conveys more or less information about the other assets (Booyson *et al*., 2005). The higher the sum total of net coefficient or the closer the sum total of net coefficient is to one, the better the standard of living of the respondents.

RESULTS AND DISCUSSION

The result in Table 1 shows that majority (75%) of Non Beneficiary farmers owned a radio, TV, Mobile Phones, goats and sheep's while a very few (25%) of Non beneficiary farmers owned a car, truck, power tillers. The source of water supply, and type of roofing materials used by the non-beneficiary homes, vary across households with majority (75%) using shallow well water and grass materials for roofing. In ABP beneficiary's homes, majority (75%) of households owned all/most of the assets listed, and had a tap water in their abodes with variation in type of sanitation facility. The walls of their building are made of cement block unlike the non-beneficiary farmers whose majority (75%) of their buildings is made of clay blocks. In non-beneficiaries homes, few households have assets/sanitation facility. The major sanitation facilities in non-beneficiaries' homes are dug hole and latrines. Table 1 shows the mean, standard deviation and percentile distribution of the assets consider in this study.

Table 1: Assets Description of ABP Beneficiaries and Non-beneficiaries Rice Farmers

	ABP Beneficiaries Descriptive Statistics							Non ABP Beneficiaries Statistics						
	Mean	SD	Min	Max	25th	50th	75th	Mean	SD	Min	Max	25th	50th	75th
Cattles	.12	.320	0	1	.00	.00	.00	.22	.414	0	1	.00	.00	.00
Livestock & Poultry	.89	.317	0	1	1.00	1.00	1.00	.65	.476	0	1	.00	1.00	1.00
Crops	.96	.185	0	1	1.00	1.00	1.00	.79	.409	0	1	1.00	1.00	1.00
TV	.86	.346	0	1	1.00	1.00	1.00	.82	.382	0	1	1.00	1.00	1.00
Radio set	.94	.239	0	1	1.00	1.00	1.00	.97	.157	0	1	1.00	1.00	1.00
Mobile Phone	.94	.239	0	1	1.00	1.00	1.00	.94	.239	0	1	1.00	1.00	1.00

Bicycle	.15	.359	0	1	.00	.00	.00	.13	.335	0	1	.00	.00	.00
Motorcycle	.79	.411	0	1	1.00	1.00	1.00	.81	.396	0	1	1.00	1.00	1.00
Car	.07	.261	0	1	.00	.00	.00	.08	.269	0	1	.00	.00	.00
Truck	.01	.112	0	1	.00	.00	.00	.01	.071	0	1	.00	.00	.00
Tractors	.03	.157	0	1	.00	.00	.00	.03	.157	0	1	.00	.00	.00
Power tillers	.08	.276	0	1	.00	.00	.00	.08	.276	0	1	.00	.00	.00
Harvesters	.03	.178	0	1	.00	.00	.00	.05	.214	0	1	.00	.00	.00
Borehole	.17	.375	0	1	.00	.00	.00	.08	.265	0	1	.00	.00	.00
Shallow well unprotected	.07	.248	0	1	.00	.00	.00	.89	.308	0	1	1.00	1.00	1.00
Shallow well protected	.26	.442	0	1	.00	.00	1.00	.07	.252	0	1	.00	.00	.00
Stream	.05	.214	0	1	.00	.00	.00	.05	.208	0	1	.00	.00	.00
Grass Roofing	.27	.446	0	1	.00	.00	1.00	.23	.419	0	1	.00	.00	.00
Zinc Roofing	.49	.501	0	1	.00	.00	1.00	.81	.394	0	1	1.00	1.00	1.00
Aluminum Roofing Sheet	.01	.087	0	1	.00	.00	.00	.01	.087	0	1	.00	.00	.00
Sticks	.07	.252	0	1	.00	.00	.00	.04	.185	0	1	.00	.00	.00
Clay Blocks	.58	.493	0	1	.00	1.00	1.00	.47	.500	0	1	.00	.00	1.00
Cement Blocks	.36	.479	0	1	.00	.00	1.00	.70	.460	0	1	.00	1.00	1.00
Electricity	.85	.361	0	1	1.00	1.00	1.00	.94	.243	0	1	1.00	1.00	1.00
Burning Touches	.41	.493	0	1	.00	.00	1.00	.03	.157	0	1	.00	.00	.00
Private Generator	.03	.178	0	1	.00	.00	.00	.20	.398	0	1	.00	.00	.00
Open Field	.04	.191	0	1	.00	.00	.00	.04	.185	0	1	.00	.00	.00
Dug Hole	.38	.485	0	1	.00	.00	1.00	.25	.435	0	1	.00	.00	1.00
Latrine	.49	.501	0	1	.00	.00	1.00	.66	.473	0	1	.00	1.00	1.00
Water Cistern	.03	.157	0	1	.00	.00	.00	.33	.470	0	1	.00	.00	1.00

Source: Field Survey, 2019

Assets Scores Model

The responses of both ABP Beneficiary and Non beneficiary farmers regarding their ownership of assets captured in Table 1. Both the parties were asked if they had the assets in their homes. A simple "Yes" or "No" response was expected. Yes responses were assigned a value of 1, while No responses were assigned 0 values. The results from the PCA presented in Table 2 show the factor scores (weights of each of the asset). Asset with positive factor scores are associated with higher social economic status, and asset with negative factor score are associated with lower social economic status. However, in some studies, ownership of durable assets such as a bicycle have been attributed a negative weight from PCA (Gwatkin *et al*., 2000; McKenzie 2003). This implies, all things being equal, that a household with a bicycle will be ranked lower in terms of social economic status than a household that does not own a bicycle. The reason for such a result may be due to ownership of a bicycle being more strongly correlated with variables that are expected to be associated with lower social economic status, for instance, lower quality housing and sanitation conditions. In estimating the value of an asset, the researchers estimate the value of not owning the asset as well as the value of owning it. Table 2 present values of owning an asset and values of not owing the asset. The difference between the components values of owing an asset and not owing the asset is the net value of the asset. The table further shows the individual item scores for each asset as well as the net asset scores for both beneficiary and non-beneficiary farmers. Table 3 shows the net asset score for non-beneficiary farmers is a negative value of - 0.022 indicating that most of the non-beneficiary farmers belong to the lowest quintile of the wealth distribution while that of ABP beneficiary farmers is a positive value of 0.061 indicating that majority of the beneficiary farmers belong to the highest wealth quintile and have improved their livelihood more than non-beneficiary farmers.

Table 2: Farmers assets score

Assets	**Non-Beneficiaries Scores**			**Beneficiaries Scores**		
	Owning (Yes)	Not Owning (No)	Item Score	Owning (Yes)	Not Owning (No)	Item Score
Cattles	-0.232	-0.19	-0.042	-0.92	-0.921	0.001
Livestock & Poultry	0.303	0.099	0.204	0.892	0.812	0.08
Crops	0.341	0.093	0.248	0.906	0.903	0.003
TV	-0.254	-0.07	-0.184	-0.157	-0.063	-0.094
Radio set	0.129	0.065	0.064	-0.135	-0.071	-0.064
Mobile Phone	-0.175	-0.165	-0.01	-0.177	-0.121	-0.056
Bicycle	0.165	0.162	0.003	0.2	0.111	0.089

Motorcycle	-0.521	-0.341	-0.18	-0.282	-0.172	-0.11
Car	0.042	-0.055	0.097	0.099	0.037	0.062
Power tillers	0.143	0.076	0.067	0.088	0.042	0.046
Borehole	0.102	0.076	0.026	0.196	0.125	0.071
Shallow well protected	0.553	0.351	0.202	-0.066	-0.065	-0.001
Stream	0.161	-0.021	0.182	-0.07	-0.071	0.001
Zinc Roofing	0.928	0.916	0.012	0.778	0.857	-0.079
Clay Blocks	0.867	0.911	-0.044	0.421	0.345	0.076
Cement Blocks	-0.799	-0.841	0.042	0.011	-0.12	0.131
Electricity	0.244	0.113	0.131	0.489	0.616	-0.127
Open Field	-0.073	0.003	-0.076	-0.322	-0.167	-0.155
Dug Hole	-0.166	-0.063	-0.103	0.155	0.329	-0.174
Latrine	0.897	0.909	-0.012	0.898	0.822	0.076
Water Cisterns	-0.042	0.021	-0.063	0.576	0.323	0.253
Total Farmers Asset Score			-0.022			0.061

Source: Researcher's computation

Table 3: Cut off points for wealth quintiles

Wealth Quintile	Asset Index Value	
	Lowest	**Highest**
Poorest	Lowest	-0.017258
Second	-0.017258	-0.02178
Third	-0.02178	-0.052324
Fourth	-0.052324	0.051588
Richest	0.52588	Highest

Source: Field Survey, 2019

CONCLUSION

Result from the study revealed that the net asset score for the ABP Non beneficiaries was a negative value of - 0.022 indicating that majority of the non-beneficiary farmers were power and score low on asset score index, while those farmers that benefited from the program had a positive value of 0.061 indicating an improvement in their livelihood as a result of the program intervention.

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FIELD TRIAL OF ADVANCED SWEETPOTATO LINES FOR AGRONOMIC QUANTITATIVE AND MARKETABLE QUALITATIVE TRAITS PREFERRED IN EXPORT MARKETS

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ABSTRACT
A Field Trial of Advanced Sweetpotato Lines for Agronomic Quantitative and Marketable Qualitative Traits Preferred in Export Markets was carried out at National Root Crops Research Institute Umudike Umuahia, Abia State in the rain fed agro-ecology of southeastern Nigeria with the following objectives: to select genotypes producing heavy commercial roots weight with high harvest index, to select genotypes possessing smooth storage root skins, good storage root shape and no cracks for export markets, to select genotypes with non-oxidizing and unique storage flesh root colour of marketable attributes that appeals to the eye. The experiment was laid out in a randomized complete block design with three replications, each plot measured 3 x 3 m. Sixteen sweetpotato clones were used for the trial. Data collection were on: total number of storage roots per plot, number of large roots per plot, total weight of storage roots in t/ha, weight of large roots in t/ha, and weight of foliage in t/ha. Marketable storage root attribute include: Storage root shape, Storage root flesh browning (oxidation), Storage flesh colour uniqueness, storage root surface defects such as cracks: The yield data were analyzed using Analysis of variance. Results indicated that the genotypes selected were based on the agronomic attributes such as high commercial fresh root weight, Marketable attributes include: non-oxidizing unique flesh colour, smooth surface skin without cracks and good shape index. Genotypes that merited these export standard with high harvest index (HI) were selected for further evaluation.

Keywords: *Sweetpotato, commercial roots, Export markets, attributes and harvest index.*

INTRODUCTION
Sweetpotato is an important food, feed and vegetable crop in many countries. The storage roots of sweetpotato are rich in carbohydrate and its leaves are rich in proteins. Orange fleshed sweetpotato varieties are rich in Beta-carotene, a precursor of vitamin A, while purple-fleshed sweetpotato varieties contain anthocyanin, which is a powerful anti-oxidant (Lebot, 2009). Globally, sweetpotato productivity in 2020 was only 89,487,835 tons on an area of 7,400,472 hectares (FAOSTAT, 2022) as compared to 543,567, 326 ton on an area of 5,334,605 hectares in 2003. In West Africa, Nigeria is the largest sweetpotato producer (3,867,871 tons) (FAOSTAT, 2022). Despite the increase, these current yields are still low by comparison with other crops like yam and cassava because of the limited yield potential of sweetpotato landraces in farmers' fields, and which are also vulnerable to an array of stresses. Yield limiting factors are lack of seed vigour and slow growth after planting, low harvest index, low or no response to inputs like fertilizer and exposure to various biotic and abiotic stresses. Major abiotic limiting factors to sweetpotato storage root and vine production are low moisture availability and non-adaptability to various types of soils though localized do cause substantial yield loss as a result export opportunities for the crop becomes limited. The average yield of sweetpotato in Nigeria is 6t/ha and is 83% lower than the world average of 35t/ha (FAO, 2007). The reason for low yield are occurrence of various biotic and edaphic factors at different growth stages. Being a tropical crop, sweetpotato is grown during and post rainy season. As a result, soil water deficit during sweetpotato establishment and mainly during root bulking emerges as the major yield constraints along with the rising temperature. Deficiencies in soil nutrients are also observed locally as other militating factors. For example, organic matter deficiency has been identified as a limiting factor in some part of the country.

Additional constraints to sweetpotato storage root and vine production include agronomic problems such as inability of some developed varieties to compete with weeds. Adequate variability for many of the crops genetic constraints exists within the sweetpotato gene pool and all these constraints affect sweetpotato marketability in both quantitative and qualitative traits and all these hindered the crop potential as article of international trade. There is a need of high harvest index (HI), and breeders consider a HI of 45 to 55% closer to optimal (Grüneberg *et al*., 2015). Storage Root Yield and HI had the same correlation profiles with their trait stability (Andrade *et al*., 2016), suggests the possibility on indirect selection for storage root yield and its stability through selecting simultaneously for a high harvest index. Therefore the objectives of this trial were: to select genotypes producing heavy commercial roots weight with high harvest index, to select genotypes possessing smooth storage root skins, good storage root shape and no cracks for export markets, to select genotypes with non-oxidizing and unique storage flesh root colour of marketable attributes that appeals to the eye.

MATERIALS AND METHODS

The trial that was conducted at the Western experimental field of NRCRI, Umudike was for assessing the advanced sweetpotato breeding lines for agronomic quantitative and marketable qualitative traits of storage roots for export potential. The trial comprised of 16 clones (14 genotypes and 2 checks). The site for the experiment was cleared, ploughed, harrowed and ridges constructed and spaced 1m apart. The experiment was laid out in a randomized complete block design with three replications. There were 16 plots replicated 3 times which gave a total of 48 plots, each plot measured 3 x 3 m which was a plot size of 9m^2 that comprised of 3 ridges with length of 3m long. Sixteen sweetpotato clones were used for the trial. The sweetpotato vines were cut 25 cm long, with at least 4 nodes. The seeds were inserted two nodes on the crest of the ridges in a slanting position and placed 1m between ridges and 0.3m apart along the row on the ridge. Weeding was manually done three times, using the West African hoe and subsequent hand pulling of tall weeds until harvested. Cross bars were constructed to control erosion and conserve soil moisture.

Data collection and analysis: At harvest, agronomic plant attributes collected were: total number of storage roots per plot, number of large roots per plot, total weight of storage roots in t/ha, weight of large roots in t/ha, and weight of foliage in t/ha.

Marketable storage root attribute include:

Storage root shape: This was visually observed. Score 1= long or round elliptic and 2 = long irregular or curved (Huamán and Zhang, 1997).

Storage root flesh browning (oxidation). This was tested by cutting the freshly harvested storage root and cut in cross section, expose the surface to the atmospheric air for 5 to 10 seconds and observe the cut surface for browning (oxidation), Score using 1 to 5. (Rate as 1= no browning, 2 = little browning, 4 = more browning, 5= abundant browning) (Huamán and Zhang, 1997).

The Storage flesh colour uniqueness: The freshly harvested storage root was washed and dried, the storage root was cut at the middle in longitudinal section. The flesh colour was compared for uniqueness/secondary flesh colour that appeals to the eye. Score 1 = appeals to the eye. 2 = no appeal to the eye (Huamán and Zhang, 1997).

The storage root surface defects such as cracks: The surface storage root was observed for cracks and rated using the scale 1 to 9. Where 1 = very low, 2 = low, 3 = intermediate, 4 = high, and 5 = very high (Huamán and Zhang, 1997).

Data Analysis: The data collected on agronomic yield were analyzed using Analysis of variance (ANOVA) and means between test genotypes were compared using standard error of difference. Procedures for performing these comparisons in ANOVA.

RESULTS AND DISCUSSION

Yield performance: The stand count at harvest, total number of storage roots, number of storage roots, total weight of fresh roots, weight of fresh roots, weight of above ground biomass and the harvest index are presented in Table 1.

Table 1: Stand count at harvest, number and weight of storage roots, dry matter content and harvest index of the advanced sweetpotato genotypes evaluated

Genotypes	Total number of storage roots/9m^2	Number of commercial roots (>100g)/9m^2	Total weight of fresh storage roots (t/ha)	Weight of fresh commercial roots (t/ha)	Weight of above ground biomass (t/ha)	H I
Cemsa 74-228	40.0	21.0	10.8	10.4	10.2	0.5
87/OP/195	56.0	36.0	16.2	10.8	6.6	0.7
PGA14442-1	34.0	23.0	11.2	8.4	7.2	0.6
PG17362-N1	42.0	33.0	8.2	6.4	7.6	0.5
NRSP/UYT/420	0.0	0.0	0.0	0.0	9.0	0.0
Buttermilk	38.0	29.0	12.6	10.2	5.3	0.7
NRSP/2019/490 (Smiles	54.0	32.0	16.6	14.2	4.0	0.8
NRSP/2019/580 (Amaok	56.0	31.0	19.5	15.0	4.2	0.8
NAN	28.0	19.0	12.3	11.3	5.1	0.7
PGA14398-4	72.0	36.0	12.0	8.1	3.9	0.7
PGA14351-4	40.0	30.0	8.8	6.8	3.2	0.7
PGA16021-39	18.0	12.0	9.5	7.5	5.3	0.6
PGA14008-9	34.0	26.0	10.6	10.0	5.2	0.7

NRSP/UYT/601	28.0	21.0	12.6	12.2	4.2	0.8
UMUSPO/3 (chk)	22.0	14.0	10.8	6.1	4.3	0.7
TIS87/0087 (chk)	42.0	26.0	7.4	5.2	5.1	0.6
Mean	**36.8**	**24.8**	**11.0**	**9.05**	**5.7**	**0.6**
Minimum	**0.0**	**0.0**	**0.0**	**0.0**	**3.2**	**0.0**
Maximum	**56.0**	**36.0**	**19.5**	**15.0**	**10.2**	**0.8**
Range	56.0	36	19.5	15.0	7.0	0.8
SE	6.3	5.1	3.4	3.1	2.5	0.9
ANOVA	240.2**	334.7**	5032.1**	45.7**	132.5*	=

The ANOVA results indicated significant ($p<0.01$) variation observed among the investigated genotypes in storage root yield attributes in terms of mean total number of storage roots and mean number of commercial roots. Also significant ($p<0.01$) mean total storage root weight and mean weight of commercial roots was observed. However, the harvest index (HI) for estimating the genotypes yield performance per unit areas was not significant ($p>0.05$) for the genotypes. The results are presented in Table 1.

Number of storage root per plot: Mean total number of storage roots indicated the number of large storage/commercial root yield and number of small root performance of the genotypes evaluated during the trial. The mean minimum number of total storage roots was 0.0t/ha (NRSP.UYT/420) while the maximum mean number of total roots was 56.0 per plot of 9m^2 (NRSP/UYT/580). Mean total number of storage roots showed the yield potential of a genotypes which comprised both the large/commercial roots and small /non-commercial roots of a genotype. The mean minimum number of large/commercial roots produced by the genotypes was 0.0t/ha (NRSP/UYT/420), while the maximum number of commercial roots was 36.0 (87/OP/195 and PGA14398-4) per plot of 9m^2 respectively. This was followed by NRSP/UYT/490 (Smiles) with 32.0 number of storage roots per plot of 9m^2. High number of commercial roots are for marketability. However, genotypes are bred to ensure that they have quantitative traits that are acceptable to domestic and international markets. These genotypes produced high number storage roots per plot of 9m^2 more than the two check varieties (UMUSPO/3 with 14.0 and TIS87/0087 with 26.0 per plot of 9m$^{2)}$. High number of storage roots is a good agronomic trait that should be given consideration for sustaining fresh of storage roots for export markets.

Weight of fresh roots: The mean minimum total fresh root weight produced by the genotypes under investigation was 0.0t/ha (NRSP/UYT/420) while the maximum mean total fresh root weight was 19.5t/ha (NRSP/UYT/580) followed by 16.6t/ha (NRSP/UYT/490 (Smiles) with range of 19.5t/ha. The total storage root weight included the weight of small roots which were not for export. The genotypes that gave minimum weight of commercial fresh roots for domestic and international trade was NRSP/UYT/420 that gave 0.0t/ha while the genotypes that yielded the mean maximum weight of commercial root was NRSP/UYT/580 with 15.0t/ha followed by NRSP/UYT/490 (Smiles) with 14.2t/ha. These genotypes produced heavy fresh root weight higher than the two check varieties UMUSPO/3 and TIS87/0087 that yielded 6.1t/ha and 5.2t/ha respectively. In this study, consideration was given to genotypes that had high storage root weight since in domestic and export trade, sales of storage roots are measured in kilogram. Genotypes with agronomic traits such as heavy weight of commercial roots were given consideration to be acceptable to international markets. According to FAO (2007), these genotypes also yielded more than the average yield of sweetpotato in Nigeria which is 6t/ha. Genotypes yielding heavy weight of storage roots also have high Harvest index. This indicated that their yield per unit area is very high and should be selected for cultivation for sustaining domestic and export market for fresh root yield (Table 1). The genotype NRSP/UYT/420 produced no storage root. However, the genotype could be maintained and cultivated for livestock fodder. Animals such as cattle and pigs cherish the consumption of sweetpotato leaves. Potential storage roots is different from commercial storage roots which are potential for marketing.

Marketable qualitative storage root traits of the genotypes: Many of the traits needed for domestic markets are the same as those needed for export markets. The Marketable qualitative traits of the sweetpotato genotypes evaluated for export potential are presented in Table 2.

Table 2: Marketable qualitative traits of the sweetpotato genotypes evaluated for export potential

Genotypes	Flesh root browning (oxidation< 5mins)	Storage root shape	Skin colour	Storage root flesh colour	Storage root surface defect/cracks	Flesh colour eye appeal
Cemsa 74-228	1	1	LP	LY	1.0	1.0
87/OP/195	1	1	Pink	DO	1.0	1.0
PGA14442-1	1	1	P	C	1.0	1.0
PG17362-N1	1	1	LP	C	1.0	1.0
NRSP/UYT/420	1	1	P	W	1.0	1.0

Buttermilk	1	1	C	Milk	1.0	1.0
NRSP/UYT/490 (Smiles	1	1	O	DO	1.0	1.0
NRSP/UYT/580	1	1	O	DO	1.0	1.0
NAN	1	1	LP	DO	1.0	1.0
PGA14398-4	1	1	LP	Y	1.0	1.0
PGA14351-4	1	1	LP	Y	1.0	1.0
PGA16021-39	1	1	LP	Y x O	1.0	1.0
PGA14008-9	1	1	LP	LY	1.0	1.0
NRSP/UYT/601	1	1	LP	W	1.0	1.0
UMUSPO/3	1	1	O	DO	1.0	1.0
TIS87/0087	1	1	LP	C	1.0	1.0
Mean	1	1	=	=	1.0	1.0

Note: SKIN COLOUR: O = Orange, LP= Light pink, P = Pink, C = Cream; FLESH COLOUR: Orange, DO = Deep orange, W = white, C = Cream, Y = Yellow, LY = Light yellow, M = Milky. **Oxidation:** 1= no browning, 2 = little browning, 4 = more browning, 5= abundant browning). **Storage root shape**: Score 1= long or round elliptic, 2 = long irregular or curved. **Flesh colour appeals to eye**: Score 1 = appeals to the eye. 2 = no appeal to the eye.

Some qualitative traits evaluated included the following

Storage root shape: All the genotypes have storage root shape score of 1.0 which means that all the storage roots produced by the sweetpotato genotypes were elliptic and oval elliptic. Therefore no long irregular shaped storage roots.

Storage root flesh colour: The flesh colour of the sweetpotato genotypes ranged from cream, white, and yellow to deep orange. The uniqueness of the fleshed colour of the storage roots of the sweetpotato genotypes indicated the varied utilization the storage roots could be put into in the export markets. The white/cream fleshed storage roots could be used for processing flour for other confectioneries. The yellow and orange fleshed storage roots could be used in both domestic and export market for processing baby food as well as using all the colours for food and feed or humans and animal population and to improve health. Breeding for different flesh colours has become increasing important market traits as marketers and consumers have more choice and become more sophisticated in their preferences (Issa et al, 2022). Quality traits such as protein and amino acids concentration are lesser concern and not physical attributes. The average score of 1.0 for the eye appeal of the storage root flesh indicated that the flesh colour of the storage roots were all pleasant to the eye and could command high market value.

Non-browning/oxidation of storage root flesh colour: The oxidation rate of the score of 1.0 showed that the sweetpotato storage root flesh colour did not brown after cutting. This was a good marketable attributes. The non-oxidizing white, yellow or orange fleshed sweetpotato appealed to the eye. All the sweetpotato genotypes evaluated were non- oxidizing storage root fleshed.

Storage root surface defects/cracks: All the sweetpotato roots harvested has score rating of 1.0 which indicated absence of cracks and constriction. Surface root defects such as cracks and constrictions lower the marketability attributes of the sweetpotato fresh root in the international market (Huamán and Zhang, 1997). The genotypes evaluated yielded storage roots that were crack and constriction free and other surface root skin defects such as alligator skin. Surface skin restrictions hamper sweetpotato root skin peelings during processing of the storage roots for food. Physiological cracks on the sweetpotato roots reduced the shelf life of the sweetpotato fresh root by predisposing the fresh storage roots to rot.

CONCLUSION

Genotypes were selected based on their agronomic marketable attributes such as high commercial fresh root weight and other marketable attributes such as non-oxidizing, unique flesh colour, smooth surface skin without cracks and good shape index. Genotypes that merited these export standard had high harvest index (HI) and were; White/Cream fleshed genotypes: Cemsa 74-228 10.0t/ha with HI of 0.5, Buttermilk 10.2t/ha with HI of 0.7, PGA14008-9 10t/ha with HI of 0.7, NRSP/UYT/601 12.2t/ha with HI of 0.8, Orange Fleshed Genotypes: NAN 11.3t/ha with HI of 0.7, PGA16021-39 = 7.5t/ha with HI of 0.6, NRSP/2019/490 (Smiles) = 14.2t/ha with HI of 0.8, and PGA14442-1 = 8.4t/ha with HI of 0.6, These genotypes yielded more than the two reference varieties UMUSPO/3 6.1t/ha and TIS87/0087 5.2t/ha. NRSP/2019/580 =15t/ha with HI of 0.8 and 87/OP/195 = 10.8 with HI of 0.7. However, the performance of a genotype is influenced by its genotype and the environment in which it is grown. It is therefore recommend to test these genotypes across the country for possible release for export trade.

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DETERMINANTS OF EXTENT OF MARKET PARTICIPATION ON FOOD SECURITY AMONG RURAL HOUSEHOLDS IN ZAMFARA STATE, NIGERIA.

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ABSTRACT

The paper examined the determinants of extent of market participation on food security among rural households in Zamfara state, Nigeria. ***.*** *Multi-stage sampling procedure was employed to select a sample size of one hundred and sixty (160) respondents for the study. Primary data were sourced from structured questionnaire designed in line with the study objectives. Both descriptive and inferential statistics were used for data analysis. The results of the study showed that 37.5% of the respondents were within the age range of 40-49 years of age with a mean age of 43years. Male formed the majority of market participants in the study area with 71.9% respondents while female constituted 28.1%. The coefficient of household size was positive and significant at 10% level of significance indicating that as the number of household members' increases, the quantity of produce sold in the market also increases. Farm income was significant at 5% significant level indicating that as income of household increase, market access also increases. Primary occupation and market participation were both negative and significant at 1%. The marginal effect shows that farmers who are fully into farming and participated in the markets had fewer chances of being food secured than their counterparts. It is concluded that market access will not only lower transportation costs but will also increase the accessibility of low-cost food items at the neighbourhood level. It is recommended that government and non-governmental organizations should form policies which will improve rural farm household income. Also, farmers should be encouraged to develop entrepreneurship skills in order to increase farm household off-farm income.*

Keywords: *Determinant, Market Participation, Food Security, Rural Households*

INTRODUCTION

Nigeria is the most populous country in Africa, with majority of the households being food insecure, especially the rural farming households. Several evidences have suggested that majority of the world's food insecure live and work in the rural areas (IFAD, 2019). This indicates that reducing rural food insecurity is very important to reducing overall food insecurity. Given the role of agriculture in the Nigerian economy, food insecurity and poverty could be attributed to the poor performance of the agricultural sector, which in turn, creates food availability and accessibility problems at the household and national levels (Agboola, 2014). In other words, the poor performance of the sector directly creates supply shortages and indirectly creates demand shortages by denying the rural farming households access to sufficient income. The Nigerian economy, in terms of revenue and foreign exchange, is undoubtedly dominated by the oil sector but agriculture holds the key to sustainable development of the country with respect to provision of employment opportunities, the provision of raw materials for agro-industries, as a source of income for rural families, and perhaps most importantly, provision of food for the population. The right to an adequate standard of living including food security is recognized in the universal declaration of human right. It is a widely accepted fact that food is a basic necessity of life. As such, adequate intake of quality food is a key requirement for a healthy and productive life (IFPRI, 2018). Food security is defined as a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (IFAD, 2019). Food security entails ensuring sustainable access, availability and affordability of adequate quantity and quality food to all citizens to meet up with their physiological requirements (Babatunde *et al.*, 2021). The main goal of food security is for individuals to be able to obtain adequate food needed at all times, and to be able to utilize the food to meet the body's needs. Food security is multifaceted. Arene and Anyaeji (2020) identified three pillars underpinning food security; these are food availability, food accessibility, and food utilization. This infers from the concept that food security is not just a production issue.

Food security refers to a situation whereby individuals have access at all times to quality and sufficient food resources to maintain a healthy and active life. On the other hand, food insecurity exists when there is constrained physical and economic access to secure sufficient quantities of nutritionally adequate food to allow individuals sustain an active and healthy living (Agboola, 2014). Food insecurity comes with unpleasant conditions with consequences detrimental to human health, well-being and productivity (Babatunde *et al*., 2021). It is against this backdrop that this study aims at examining the determinants of the extent of market participation among farmers in Zamfara state, Nigeria. The specific objectives are to; i. describe the socio-economic characteristics of the farmers, ii. Examine the determinants of extent of market participation of the farmers.

METHODOLOGY

The Study Area

This study was conducted in Zamfara State, North-western Nigeria. The capital of Zamfara State is Gusau. The State comprises of fourteen (14) Local Government Areas, with an area landmass of 38,418 sq. km. The state stretches between Latitude 10 21/ to 13 15/N and Longitude 60 20/E. Zamfara Sate is bordered in the North by Niger Republic, in the South by Kaduna State, in the East by Katsina State and in the West by Sokoto, Kebbi and Niger States respectively, the state lies in the Sudan Savannah Agro Ecological Zone of Nigeria and has a population of 4,515,400 according to (NPC, 2017) projection of 2.47%.

Sampling procedure and Sample Size

Multi-stage sampling technique was employed to select a sample size of one hundred and sixty (160) respondents for the study. The respondents were selected in stages. In stage one, a random selection of two Local Government Areas (LGAs) in the zone were made. In stage two, two (2) villages were randomly selected from each of the two LGAs. In stage three, 2 households from each of the selected villages were chosen at random thereby giving a total number of Eight (8) households to be used as sample size for the study. In stage four (4) 20 respondents were drawn from each of the selected villages thereby giving a sample size of (160) respondents used as the sample size for the study.

Method of data collection and Analysis

Both primary and secondary data were used for the study. Primary data were sourced from structured questionnaire designed in line with the study objectives. The questionnaire were administered to one hundred and sixty (160) respondents. Descriptive statistics such as mean, frequency and percentage was used to analyse objective i. While objective ii was achieved using Tobit regression model which is called censor regression model.

Tobit model

A Tobit model is any of a class of regression models in which the observed range of the dependent variable is censored in some way.

Tobit regression

$Y_i = X_i\beta$, if $i^* = X_i\beta + U_i > T$

$= 0$; if $i^* = X_i\beta + U_i \leq T$

$i = 1, 2$……….

Where, Y_i = the dependent variable measuring the extent of market access

Yi{ 1 if $i^* > T$, if the farmer have access to the market { 0 if $i^* \leq T$, if the farmer does not have access to the market

X_i= a vector of explanatory variables, which consists of the socio-economic characteristics of the respondents in this study.

β = vector of parameters to be determined

U_i = an independently, normally distributed error term with zero means and constant variance, The explanatory variables (X_i) specified as socio-economic determinants of the extent of market access and used in the analysis are shown below:

X_1 = Age of the respondent in years, X_2 = Gender of the respondent (Dummy =1, if male; 0 if female), X_3 = Household size of respondent (number), X_4 = Educational level of the respondent (Dummy =1, if illiterate, 0 if otherwise), X_5 = Primary occupation of the respondent, X_6 = farm income of the respondent, X_7 = Remittance, X_8 = Market participation.

Table 1: Socio-economic characteristics of the respondents (n = 160)

Variables	Frequency	Percentage	Mean
Age (years)			
20-29	22	13.75	
30-39	49	30.63	
40-49	52	32.50	43 years
50-59	27	16.87	
>59	10	6.25	
Gender			
Male	115	71.87	
Female	45	28.13	
Marital Status			
Single	24	15.00	
Married	124	77.50	
Divorced	3	1.87	
Widow(er)	9	5.63	

Educational level			
No formal education	7	4.38	
Primary	19	11.88	
Secondary	84	52.50	
Tertiary	50	31.25	
Household size (persons)			
1-5	71	44.38	
>5	58	36.25	6 persons
>4.0	31	19.38	
Household income (Naira)			
100,000-200,000	90	56.25	
201,000-300,000	33	20.63	
301,000-400,000	17	10.63	
401,000-500,000	8	5.00	₦199,045.6
>500,000	12	7.50	
Total	**160**	**100.00**	

Source: Field Survey, 2023

Table 2: Regression results of the determinants of extent of market participation on food security

Variables	Coefficient	Std. Err	t – value	p>ǀzǀ
Age	195.39	165.9442	1.18	0.242
Gender	21.382	3375.039	0.01	0.995
Household size	2723.9	775.8447	3.51	0.001***
Education level	4074.6	2210.35	1.84	0.069*
Primary occupation	3713.5	1355.96	2.74	0.007***
Farm income	0.0132	0.00532	2.48	0.015**
Remittance	-0.058	0.1000	-0.58	0.556
Market participation	26.85	9.6795	2.77	0.007***
Constant	-3839.73	13175	-2.91	0.005

Source: Field survey, 2023 *significant at 10% level, **significant at 5% level, ***significant at 1%level

The result in Table 1 showed that majority of the respondents were male accounting to (71.88%) while female was (28.13%). This suggests that there were more male household heads in the study area. Farming is a labour intensive enterprise, hence male dominance is paramount. The result further agrees with the findings of (Ishaku, 2017) who reported that farming is male dominant while female are more involved in processing of agricultural products. The implication of male dominance in market participation is to ensure that their households are food secured because they are vested with the responsibility of meeting their household nutritional needs. The result of the study shows that 13.75% of the respondents fell within the age range of 20 - 29, 6.25% were above 59 years of age. Most of the respondents were less than 59 years old. The result of the study shows that 77.50% of the respondents were married, 15% were single, 5.63% of the respondents were widows and 1.88% of the respondents were divorced. Opeyemi *et al.*, (2020) opined that the significance of marital status on agricultural production can be explained in terms of the supply of agricultural family labour. It is therefore expected that family labour would be more available where the household heads are married. The results in table 1 further revealed that higher percentage of the farmers in the study area have a household size ranging 1 - 5, and 49.38% have a household size of above 5. The mean household size in the study area is approximately 6 persons. As indicated in the table 1, only (3.75%) of the respondents did not have any form of education, 52.50% had secondary education and 31.25% had tertiary education. Further results indicated that 56.25% of the respondents generated an income of ₦100, 000 - 200,000 annually, and more than ₦ 500,000 annual farm income were generated by 7.5% of the farmers in the study area. The regression result shows that as the household size, primary occupation, education and income of the household improves, the probability of household's participation in marketing increases.

CONCLUSION AND RECOMMENDATIONS

The study determined extent of market participation on food security among rural households in Zamfara state, Nigeria. A multistage sampling technique was used to select 160 respondents. The households were interviewed with the use of questionnaire which were administered in line with the objectives of the study. The households were selected from two Local Government and two communities from each of the Local Governments. The Tobit Model results also reveal that an increase in household's size and household's income increases their likelihood. Based on the findings of this study, it is recommended that interventions should be provided and should focus on improving smallholder farmers' market participation, such as selling their produce collectively so that they will be able to supply large retail stores. Government and non-governmental organizations should form policies which will improve rural farm household income. Also, marketers should be encouraged to develop entrepreneurship skills in order to increase farm household off-farm income.

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ANALYSIS OF COST AND RETURNS OF PLANTAIN PRODUCTION IN TAI LOCAL GOVERNMENT AREA, RIVERS STATE

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ABSTRACT
The study analyzed costs and returns of plantain production in Tai Local Government Area of Rivers State, Nigeria. Objectively, the study described the socio-economic characteristics of plantain producers, estimated the costs and returns of plantain production, and identified the constraints associated with plantain production in the study area. Using survey research design, copies of structured questionnaire were administered to 90 farmers by simple random sampling technique and the emanating data were analyzed with the use of descriptive statistics, mean score, and gross margin. On socioeconomic characteristics, the result showed that 55.6% of the plantain farmers were male against 44.4% whom were female. Also 54% of them were between the ages of 31-35 years and 17.8% were between the ages of 44-56 years. On education status, 40% of the farmers had secondary education, 34% of them had primary education, and 25.6% of the farmers had tertiary education. Gross margin analysis showed that, the annual variable cost of plantain production was ₦2,133,056 which accounted for a gross margin of ₦309,167.00. In addition, the estimated average annual profit of the plantain farmers stood at ₦2,075,577, an indication of the profitability of plantain production. Result on the constraints associated with plantain production showed that lack of storage facility and theft were the major constraints identified having a respective mean score of 3.61 and 3.17. The study recommended that Government and civil society should work to enhance security in rural areas to curb the incidence of theft of agricultural produce.
Keywords: *Plantain production, Plantain farmers, Costs and returns*

INTRODUCTION
Nigeria is one of the largest plantain producing countries in the world and despite its prominence, Nigeria does not feature among plantain exporting nations because it produces more for local consumption than for export (FAO, 2011). Plantain is a versatile food in the kitchen as well as a raw material for many popular delicacies and snacks. This reason and the growing population of Nigeria gave way to the enormous increase in demand for the crop in the consumers market (Aina *et al.*, 2012). Among plantain products are plantain flower, chips, beer and ethanol. The ripe ones are sliced and fried in oil as "dodo". Over-ripe ones are both compacted and fried in oil as "dodo Ikire" or mixed with plantain flour to make "ekuru", a delicious local dish (Aina *et al*., 2012).
The growing of plantain is left in the hands of subsistence farmers who account for about 80% of Nigeria`s agricultural output. The crop is grown in the backyard or home stead and recently in plantations for the commercial market (Aina et al., 2012). Perhaps, this drawback explains why the demand for plantain surpasses the supply such that, plantain is becoming more and more expensive in Rivers State (Alagoa, 1999). To harness the economic potentials of plantain, the current level of its production must be improved. This implies that the limited resources available to plantain have to be used efficiently. The poor plantain output problem in Nigeria therefore centers on the efficiency with which farmers use resources on their plantain farms. It also borders on how the various factors that affect plantain production can be examined so as to increase plantain production in the Nigeria.

Objective of the Study
The specific objectives of this study were to:
i. describe the socio-economic characteristics of plantain producers in the study areas;
ii. estimate the costs and returns of plantain production in the study area; and

iii. identify the constraints associated with plantain production in the study area.

MATERIALS AND METHODS

The study was conducted in Tai Local Government Area (LGA), Rivers State Nigeria. Tai has an area of 159km2 and a population of 117,797 and a projected population of 173,000 in 2022 (NPC, 2022). The LGA lies between latitudes 4° 43' and 7° 18'N of the equator and longitudes 4.72°and 7.30°E of the Greenwich Meridian. The LGA is within the tropical climate and experiences two distinct seasons, the rainy season and the dry season. Tai LGA has two broad sections: the Tua Tua Kingdom and the Barasi Nonwa Kingdom, both under the overall Tai Kingdom. The primary occupations are farming, and fishing to a lesser degree.

Survey research design was employed by the study and copies of structured questionnaire were used in obtaining the data. In respect to the study population, the Rivers State Ministry of Agriculture (2018) gave an estimate of 105 registered plantain farmers in the LGA. Therefore, 105 plantain farmers served as the population of this study. Thus with a level of significance of 5%, the Taro Yamane (1967) formula yielded a sample size of 83 plantain farmers and for the purpose of equal allocation among the communities selected in the study area, the study increased the sample size to 90 plantain farmers.

Multi-stage sampling procedure was used in selecting the sample size of the study. The first stage involved the purposive selection of ten (10) communities out of the seventeen (17) communities in Tai LGA was employed. This was owing to the fact that there were more plantain farmers' concentration in the selected communities. The second stage involved the simple random selection of nine (9) farmers in Botem, Kpite, Korokor, ueken, Bunu Nonwa, Sime, Kira, Borobara and Gbene-ue, thus making a total of 90 respondents.

Objective (i) was achieved using frequency count and percentages. Objective (ii) was achieved using gross margin analysis objective. Objective (iii) was analyzed using mean score.

Gross Margin

Gross margin mode was used to determine the costs and returns from gross margin obtained; further analysis was conducted to obtain profit associated with the trade in the study area. The model is specified as:

$GM = TR\text{-}TVC$ equ.1

Where: GM = Gross margin; TR = Total revenue; TVC = Total variable cost; TFC = Total fixed cost; and π (profit) = GM-TFC

Likert Scale Rating Technique

The 4-point Likert scale rating technique was used particularly in identifying problems associated with plantain production. This was done on a four-point basis. According to Umoinyang (2014) the 4-point scale rating technique does not give room for the respondents to be indifferent. The rating is presented in the following order:

Strongly agreed (SA) = 4; Agreed (A) = 3; Disagree (D) = 2; and Strongly disagree (SD) = 1.

The mean scores of the respondents based on the 4-point scale was 4 + 3 + 2 + 1 = 10, 10/4 = 2.5.

Benchmark: The benchmark using the four-point Likert Scale to analyze the constraints militating against plantain production was 2.5. The 2.5 benchmark indicates that mean values from 2.5 and above shows that the parameter is a constraint.

RESULTS AND DISCUSSION

Socio-economic Characteristics of the Respondents

The socio-economic characteristics of plantain producers in the study area are presented Table 1. Table 1 shows that 55.6% of the respondents were males, while 44.4% of them were females. This may imply that because, plantain bunch is bulky and the sucker grows to it may require more of masculine energy to cultivate. Furthermore, 54.4% of the farmers were within the age of 31-43 years, 17.8% were within the age of 44-56 years, 16.7% were of ages 18-30 years and 11.1% were greater than 50 years. This indicates majority of the respondents were young and in their active ages. According to Ibekwe *et al.,* (2010) young individuals have the ability to withstand stress and risk. On marital status, 73.3% of the farmers were single, 17.8% of them were married, and 8.9% were separated. This implies that majority of the respondents were single. Since majority were single, it would mean that they would invest more time and resources in their plantain farms since there would be little or no distraction from family obligations and commitments. The result on household size shows that 54.4% of the respondents had household size of 2-4 persons and was followed by 25.6% of the farmers who had household size of 5-7persons. Entries on farming experience shows that 38.9% of the respondents had greater than 9 years of experience in plantain production while 26.7% of them had 1-3years experience. Years of experience in agricultural production is handy in lowering risk suffered by farmers. It can be applied in areas of farm financing, product storage and marketing and can also be of use in sourcing for farm inputs which may eventually translate into increase in farm profit or reduction in farm cost. Result on educational attainment shows that 40% of the farmers received secondary school education, 34.4% of them received primary school education, and 25.6% of them had tertiary educational attainment. This indicates that majority of the respondents had secondary school educational attainment. This also implies that all the respondents were educated as they had one form of formal education or the other. Higher educational level or literacy level can lead to better adoption of farm technology in agriculture. This result is in agreement with the observation of Kainga and Seiyabo (2012) which stated that majority of their respondents were educated. Table 1 further shows the majority (45.6%) of the plantain farmers earned ₦41,000 - ₦80,000 monthly. The Table also shows that majority (55.6%) of the farmers had farm size of 1-3 plots.

Table 1: Socioeconomic Characteristics of the Respondents (n = 90)

Characteristics	Frequency	Percentage (%)	Mean
Gender			
Male	50	55.6	
Female	40	44.4	
Total	90	100	
Age (Years)			
18-30	15	16.7	
31-43	49	54.4	40 years
44-56	16	17.8	
> 56	10	11.1	
Total	90	100	
Marital status			
Single	66	73.3	
Married	16	17.8	
Separated	8	8.9	
Total	90	100	
Household size (Person)			
2 – 4	49	54.4	
5 – 7	23	25.6	5 persons
8 – 10	8	8.9	
>10	10	11.1	
Total	90	100	
Farming experience (Years)			
1-3 years	24	26.7	
4-6 years	15	16.7	
7-9 years	16	17.8	7 years
> 9 years	35	38.9	
Total	90	100	
Educational attainment			
No formal education	0	0	
Primary	31	34.4	
Secondary	36	40	
Tertiary	23	25.6	
Total	90	100	
Monthly Income (₦)			
10000-40000	34	37.8	
41000-80000	41	45.6	
81000-120000	8	8.9	₦56866.6
>120000	7	7.8	
Total	90	100	
Farm size (Plot)			
1-3 plots	50	55.6	
4-6 plots	33	36.7	3.56 plots
>6 plots	7	7.8	
Total	90	100	

Note: 1 hectare = 15 plots of land
Source: Field Survey, 2022

Costs and Returns of Plantain Production

Table 2 presents the costs and returns analysis of plantain production. Result shows that the total variable cost of production per annum was ₦2,133,056 and the total revenue was given as ₦2,442,222. The average annual gross margin for plantain production stood at ₦309,167.00 followed by an annual profit of ₦2,075,577. The rate of return on investment of ₦6.67 was obtained by (TR/TC), implying that for every ₦1 invested ₦6.67. Overall, this result shows that plantain production is profitable and is supported by the findings of Agbagwa *et al.* (2021).

Table 2: Average Annual Costs and Returns on Plantain Farming

Items	Amount (₦)
Total Revenue (TR)	**2,442,222**
Cost of plantain seedling	266,386.7
Fertilizer	16097.56
Herbicide	24280
Labour	28,702
Total Variable Cost (TVC)	309,167
Gross Margin (GM)	**2,133,056**
Depreciation	3,392
Rent on Land	54086.67
Total Fixed Cost (TFC)	57,478
Total Cost (TC)	**366,645**
Profit (TR – TC)	**2,075,577**
Net return on Investment (TR/TC)	6.67

Source: Field Survey, 2022

Constraints Associated with Plantain Production

The problems associated with plantain production as identified by the respondents are presented in Table 3. The result shows that the most dominant constraint was the lack of storage facility with mean score of 3.61. The economic implication of this finding is that, since plantain is a perishable commodity, its producers will likely suffer loss when it is not quickly disposed in the market place. Incidence of theft had mean score of 3.17. Theft of plantain will adversely affect the profit of the farmer and could weaken his/her ability to continue production. Conversely, the plantain farmers, did not identify high cost of land and poor demand of plantain as constraints because their respective mean scores of 1.58 and 2.12 fell below the benchmark of 2.50. Availability of demand for agricultural products can serve as an incentive in fostering agricultural production.

Table 3: Constraints to Plantain Farming

Constrains	**SA (4)**	**A (3)**	**SD (2)**	**D (1)**	**Total Score**	**Freq.**	**Mean ($\bar{X}$)**
Fragmented land	8	53	30	0	251	90	2.79
High cost of land	0	7	38	45	142	90	1.58
Theft	30	45	15	0	285	90	3.17
Poor demand	9	16	42	23	191	90	2.12
Lack of storage facility	55	35	0	0	325	90	3.61
Poor roads	13	37	6	34	209	90	2.32

$\bar{X}$ >= 2.50 = important; $\bar{X}$ < 2.50 = un important

Where: SA = Strongly Agree A = Agree, D = Disagree, SD =Strongly Disagree

Source: Field Survey, 2022

CONCLUSION

From the findings gathered, the study concludes that plantain production in Tai Local Government Area is profitable. The study affirms that lack of storage facility and theft were the major constraints facing plantain production in Tai.

RECOMMENDATIONS

On the basis of the findings reached, the study recommends that:

i. Government and civil society should work to enhance security in rural areas to curb the incidence of theft of agricultural produce.
ii. Owing to the profitability of plantain production, government should train unemployed youths on skills necessary to cultivate and manage plantain farms.

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EFFECT OF NAIRA-DOLLAR VOLATILITY RATE ON EXPORT OF GINGER AND OIL PALM IN NIGERIA, 1988-2021

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ABSTRACT
This study examined the effect of naira-dollar volatility rate on export of ginger and oil Palm in Nigeria from 1988 to 2021.The study adopted quasi-experimental research design and relied on time series data. Pre-estimation diagnostics tests such as unit-root and cointegration test were adopted to check for stationarity of the data and their residuals as well as long run relationship to prevent spurious regression results. The method employed for analyzing the time series data were the fully modified OLS and the Auto Regressive Distributed Lag (ARDL) models regression method. The result showed that a-unit increase in exchange rate brought about 149.2-unit increase in ginger export. Increase in exchange rate brought about a -210.6560-unit reduction in oil palm export value. It was concluded that the naira-dollar exchange rate does not encourage gainful agricultural trading to the Nigerian economy. The study recommended that agricultural production should be increased in the country to meet domestic needs and export so that devalued naira will be beneficial in terms of volume of agricultural commodities exported.
Keywords: *Exchange Rate, Naira, Dollar, Volatility, Export*

INTRODUCTION
The economies of all countries of the world are linked directly or indirectly through asset and goods in the markets. This linkage is made possible through trade and foreign exchange. The importance of international trade in the development process has been of keen interest to development economists. With the implementation of the World Trade Organization (WTO) rules and substantial reduction in trade restrictions, most of the developing countries imports are increasing rapidly. Nigeria's economy is not an exception as it depends on the pattern of world's economy (Abolarin *et al.*, 2022). Export is considered as a major factor that determines balance of payment position of a country. When the value of export of a country exceeds the value of its import, it will improve balance of payment position (Godfrey and Cosmas, 2014). Lack of important resources in some part of the world is one of the reasons that encouraged countries today to engage in international trade transaction (Ramesh and Majed, 2021). In the case of Nigeria, her major exports components come from the agricultural products such as cocoa, palm produce, rubber as well as solid minerals resources such as lead-zinc ores, Limestone, gold among others (Oloyede and Essi, 2017). However, Ramesh and Majed (2021) has pointed out that the impact of exchange rate on export depends on the level of financial development. Mehdi *et al*. (2014) also stated that exchange rate fluctuation lead to an increase in export and economic growth when the financial markets are developed enough. However, when financial markets are undeveloped, exchange rate fluctuations will reduce export and subsequently hinder the growth of the economy.

METHODOLOGY
Study Area
The study on effect of Naira- dollar volatility rate on Ginger and Oil Palm Export (1988-2021) was conducted in Nigeria. It is a tropical land located in West Africa. It extends from about 4° to 14° north latitude, with a north–south span of about 700 miles (1,125 kilometers). In an east–west direction, the country extends from roughly 3° to 13° east longitude, also a distance of about 700 miles. The country's total area of some 357,000 square miles (925,000 square kilometers) is therefore, quite compact in shape. The country's hot and soggy southern border faces upon the equatorial Gulf of Guinea (on the Atlantic Ocean). In the north, Nigeria extends into the Sahel region, nearly reaching the parched Sahara Desert (Zhang *et al*., 2004).

Data Collection
Secondary data was used for this study. Specifically, data on Ginger and oil palm export and exchange rate (Naira to Dollar). All data were gotten mainly from the publications of FAO (2022) on statistics.

Data Analysis

The estimation method adopted for the models were the Auto Regressive Distributed Lag Model (ARDL) and the Fully Modified Ordinary Least Square (FMOLS). In other words, the ARDL method will determine the long and short run impact of exchange rate on agricultural exports in Nigeria.

Model Specification

Model One

GINGEXP = f(EXCHR) (1)

Where; GINGEXP = Ginger Export

EXCHR = Exchange Rate

The single equation Cointegration model of the FMOLS variety of equation (1) is formalized as follows:

$$GINGEXP = \ltimes_0 + \ltimes_1 EXCHR_t + \sum_{p=-y}^{n} \emptyset_1 \Delta GINGEXP_{t-y} + \sum_{p=-y}^{n} \emptyset_2 \Delta EXCHR_{t-y} + \Sigma_t \quad (2)$$

Where: GINGEXP and EXCHR are as previously defined.

$\ltimes_0 = Constant\ Term$

$\ltimes_1 = Long\ run\ Multipliers$

$n\ and\ y = Optimal\ lag\ lenght\ and\ lead\ lengths\ respectively$

$\Delta = First\ difference\ operator$

$\Sigma_t = Statistic\ error\ term$

Model Two

$OILPEXP = f$ (EXCHR) (3)

Where:

OILPEXP = Oil Palm Export

EXCHR = Exchange Rate

Equation (3) is an implicitly expressed econometric model

The model for the regression is specified explicitly as follows

$OILPEXP = a_0 + a_1 EXCHR_t + u_t$ (4)

Where:

a_0 = Constant

a_1 = Coefficients

u_t = stochastic error terms

Specifying equation (4) in ARDL Cointegration model by incorporating the lag and lead of each of the explanatory variables into the model as part of the explanatory variables.

In the short run:

$$\Delta Y_t = \alpha + \sum_{i=1}^{p} \Delta Y_t + \sum_{i=1}^{q} \Delta\beta_1 B_{t-1} + \mu_t \quad (5)$$

Now adopting the model to the study, with indication of co-integration in the long run of the variables we have:

$$OILPEXP_t = \psi + \sum_{i=1}^{p} OILPEXP_{t-1} + \sum_{i=1}^{q} \alpha_1 EXCHR_{t-1} + \mu_t \quad (6)$$

Where: ψ = intercept

β_1 = parameter estimates of the regressors in the short run

u_t = stochastic error terms.

RESULTS AND DISCUSSION

Table 1 presents the time series data of the dependent variables Ginger and Oil Palm Export and the independent variable, Exchange rate.

Table 1 Time Series Data on the Variables Used for Study from 1988-2021

YEAR	EXCHR	GINGEXP	OILPEXP
1988	4.536966667	275	8
1989	7.364735	276	15
1990	8.038285	253	37

1991	9.909491667	628	6
1992	17.298425	1347	0
1993	22.0654	805	7
1994	21.996	1038	0
1995	21.89525833	1075	0
1996	21.884425	2000	40
1997	21.88605	890	2000
1998	21.886	820	1900
1999	92.3381	3915	3900
2000	101.6973333	3316	5000
2001	111.23125	1900	5000
2002	120.5781583	1283	3250
2003	129.22235	2110	7000
2004	132.888025	6114	3500
2005	131.2743333	10581	7200
2006	128.6516667	7070	4000
2007	125.8081083	6661	12000
2008	118.5666667	6072	22500
2009	148.88	4431	10000
2010	150.2975	11275	12000
2011	153.8625	18463	11000
2012	157.5	16113	21000
2013	157.3116667	19449	16200
2014	158.5526417	32227	45900
2015	192.4403333	36557	18000
2016	253.492	39861	7200
2017	305.7901092	37541	6300
2018	306.0836882	42242	22563
2019	306.9209515	39369	3600
2020	358.8107973	51460	3000
2021	408.6008333	61272	1061

Source: Food and Agriculture Organization (FAO) (2022);
Note: EXCHR: means dollar exchange rate; GINGEXP: means Ginger export; ILPEXP: means Oil palm export

Unit Root Test
The optimal order of lag for each of the variables was based on schwartz information Criterion (SIC) automatic lag selection procedure. The table showed that the variables were stationary at level I (0) and at first difference I (1).

Table 1 Unit Root Test Result

Variable	ADF Levels	Sig.	ADF 1st Diff.	Sig.	Order of Integration
EXCHR	2.212719	0.9999	-3.625471	0.0107	I(1)
GINGEXP	-0.026827	0.9941	-4.284521	0.0020	I(1)
OIPEXP	-3.811844	0.0079			I(0)

Source: Author's Compilation, using E-views 10, 2023

The Augmented Dickey Fuller (ADF) unit root test was the stationarity test type used. The order of integration shows Exchange Rate (EXCHR), Ginger Export (GINGEXP) became stationary at first difference I (1), while Oil Palm Export was stationary at level I (0). The statistical implication of this result is that the regression result will not be spurious and the data set is good for forecasting and examining future trends.

Cointegration Test for Model One

Table 2 Summary of Johansen Cointegration Test Result for Model One

Series: GINGEXP EXCHR

Lags interval (in first differences): 1 to 1

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.230572	13.15994	15.49471	0.1091
At most 1 *	0.138552	4.772499	3.841466	0.0289
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.230572	8.387444	14.26460	0.3407
At most 1 *	0.138552	4.772499	3.841466	0.0289

Source: Author's Compilation, using E-views 10, 2023

From the Johansen cointegration test result in table 2, for model one, the variables were Cointegrated. Both trace and maximum Eigen values showed evidence of Cointegration. Thus, the null hypothesis of no Cointegration was rejected. This implies that the variables in the model have long run relationship.

Cointegration Test for Model Two

Cointegration test for model two was conducted using Bounds Cointegration test. This was so because the variables were stationary at level and first difference.

Table 3 ARDL Bounds Test for Model Two

Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	0.522840	10%	4.04	4.78
		5%	4.94	5.73
		2.5%	5.77	6.68
		1%	6.84	7.84

Source: Author's Compilation, using E-views 10, 2023

As indicated in table 3, the computed F-statistics (0.522840) is less than the upper and lower bound critical values at 10%, 5%, 2.5% and 1% level of significance, therefore, the null hypotheses of no level relationship could not be rejected. This implies that there was no evidence of co-integration in the model. This implies that there was no long run relationship between the dependent variable (oil palm export) and independent variable (exchange rate). Hence the regression will stop at the ARDL, no need for further testing of the ECM.

Regression Estimation Result for the Models

Table 4 FMOLS Regression Result for Model One

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXCHR	149.2766	18.51159	8.063954	0.0000
C	-6517.037	3171.651	-2.054778	0.0484
R-squared	0.853437	Mean dependent var		14194.36
Adjusted R-squared	0.848709	S.D. dependent var		17601.40
S.E. of regression	6846.273	Sum squared resid		1.45E+09
Long-run variance	1.29E+08			

Source: Author's Compilation, using E-views 10, 2023

The long run relationship between exchange rate and ginger export was estimated using FMOLS. It was found from the result that exchange rate has a significant positive effect on ginger export in the long run for the period under study. This was so because the p-value of 0.0000 was less than 0.05 at the 5% level of significance.

The result shows that ginger export increased by 149.2766-units as a result of 1% increase in exchange rate. The R-squared (0.853) revealed that the explanatory variable accounted for 85.3% of the overall variations in ginger export. This is an indication that the model is well-fitted.

Table 5 ARDL Regression Result for Model Two

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
OILPEXP(-1)	0.408109	0.191783	2.127974	0.0466
OILPEXP(-2)	0.130896	0.214773	0.609461	0.5494
OILPEXP(-3)	0.213315	0.226207	0.943008	0.3575
OILPEXP(-4)	0.380692	0.219135	1.737250	0.0985

OILPEXP(-5)	-0.357050	0.245238	-1.455932	0.1617
OILPEXP(-6)	0.523793	0.268543	1.950502	0.0660
EXCHR	-210.6560	84.33796	-2.497761	0.0218
EXCHR(-1)	173.8154	95.14031	1.826938	0.0835
C	6259.911	3302.165	1.895699	0.0733
R-squared	0.568399	Mean dependent var		9111.214
Adjusted R-squared	0.386673	S.D. dependent var		9928.038
S.E. of regression	7775.164	Akaike info criterion		21.01035
Sum squared resid	1.15E+09	Schwarz criterion		21.43856
Log likelihood	-285.1449	Hannan-Quinn criter.		21.14126
F-statistic	3.127772	Durbin-Watson stat		2.105095
Prob(F-statistic)	0.019673			

Source: Author's Compilation, using E-views 10, 2023

The result showed that exchange rate (EXCHR) in its current period was negatively significant in influencing changes in oil palm export for the period under study, this is evidenced by the p-value of 0.0218 which is less than 0.05 at the 5% level of significance. The implication of the finding based on the sign and magnitude of the coefficient, is that a unit increase in exchange rate brought about a -210.6560-unit reduction in oil palm export for the period under study. This finding is similar to Endurance and Nsikak (2022) who examined the effect of exchange rate on agricultural exports in Nigeria reported that exchange rate has a negative effect on agricultural exports in Nigeria.

The R^2 which measures the goodness of fit was 0.56. This implies that 56% of the total variation in oil palm export (dependent variable) was explained by exchange rate (EXCHR). The overall model was significant given the F-statistics value of 3.127772 with the probability (F-stat =0.019673). This implies that the explanatory variable was significant in explaining the changes in the dependent variable. The Durbin –Watson value of 2.10 which is not far from 2.0 indicates that there was no problem of serial auto correlation in the model.

From the findings, the exchange rate does not have a stable or predictable effect on international agricultural trading, The study concluded that the naira-dollar exchange volatility rate does not encourage gainful agricultural trading in Nigerian economy. The study recommended that agricultural production should be increased in the country to meet domestic needs and export so that devalued naira will be beneficial to us in terms of volume of agricultural commodities exported

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ECONOMIC ANALYSIS OF MARKETING OF PLANTAIN IN OSHIMILI SOUTH LOCAL GOVERNMENT AREA OF DELTA STATE

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ABSTRACT

The study was carried out to examine the structure of plantain market in Oshimili South Local Government Area, Delta State. Three towns of plantain marketers were randomly selected from four purposively selected towns with a total respondent of one hundred and twenty. Structured questionnaire was used to collect the data. Descriptive statistics, Cost and returns analysis, Return per capital invested were used to analyze the data. The study showed that majority (96%) of the plantain marketers were female. 51.7% are within the active age range of 41-50 years. Most respondents were married and educated having a household size of between 1-10 members. The cost and returns analysis showed that purchased cost, transportation, labour and storage cost constitute the variable cost while rent, tools and market charges form the fixed cost. Furthermore, the findings showed that plantain marketing is profitable with a gross margin of ₦3,867.90 per month from the sales of plantain bunches. Analysis of the profit revealed that plantain marketing is a profitable business. The constraint militating against marketing of plantain in the area were also identified to be high transportation cost, seasonal price fluctuation, rapid deterioration in quality/spoilage, inadequate funds, high initial cost of plantain, poor access road and high market charges. The study therefore recommends that plantain marketers should come together to form plantain marketers' cooperative groups from which members could obtain loans at very low interest rates. Problem of infrastructural facilities such as bad roads should be addressed by all tiers of government.

Keywords: *Economics, Profitability, Marketing, Plantain, Gross Margin*

INTRODUCTION

Plantain (*Musa paradisiaca)* is one of the most important staple food crops for millions of people both in developed and developing countries. It supplies up to 25% carbohydrate for approximately 70 million people in the humid region of Sub-Saharan Africa (Norgrove *et al.,* 2014). Plantain originated from South East Asia and Western Pacific region (John and Marchal, 1995). It belongs to the family of Musaceae, and they are of two types; *Musa acuminate* (genome AA) and *Musa balbisiana (*genome B13). However, a great diversity is said to exist in Central Africa, thus suggesting plantain to be among the oldest cultivated crops in the region (Olumba and Onunka, 2020). The consumption of plantain cuts across social, age, ethnic, religious and geographical barrier. Plantain is accepted and loved by Nigerians. Plantain is a versatile food in the kitchen. It is commonly eaten as fried ripe plantain (dodo), boiled as green plantain and eaten with palm oil or stew or roasted and eaten as snack or as porridge. This reason plus the growing population of Nigeria leads to an enormous increase in demand for the crop in the consumers' market. Plantain is the cheapest staple food crop in terms of production costs per hectare as compared to other food crops like maize and cassava (Source??). It produces fruits all year round, thus playing the role of 'the hunger-gap' between crop harvests. It gives high economic returns, reaches maturity and pays off its cost of establishment within a year. It is an important source of income for the resource-poor rural farmers. Plantain provides household food security and gainful employment to both rural and urban dwellers. Plantain production is environment-friend ly being useful in combating soil erosion and as inter-crop in mixed farming system (Federal Department of Agriculture (FDA, 2015).

Marketing of agricultural products begins at the farm level when the farmer plans his production to meet specific demands and market prospects. Plantain marketing involved all activities and services associated with the movement of produce from farmers' (producers) farms to the consumers. The role of marketing involves assembling of plantain bunches bit by bit by village collectors from the different places of production to the markets in the towns and cities. Like many other agricultural products, plantain is highly perishable. Most plantains are produced by small scale farmers who often do not have the financial resources for sustained production. These physical characteristics and challenges of plantain production present some challenges to its marketing.

Studies on plantain showed that the business of plantain marketing is profitable (Folayan and Bifarin, 2017). High transportation cost, rapid deterioration in quality and spoilage, and seasonal price fluctuations are major challenges to plantain business. Some characteristics of many agricultural commodities such as high perishability and seasonality of the commodities also contribute to the challenges of the plantain marketing business. The need for research on analysis of marketing of plantain became necessary in order to understand plantain marketing situation particularly in Oshimili South Local Government Area (LGA) of Delta State and to achieve good performance and efficiency in its marketing.

Objectives of the Study

The broad objective of this study is to analyze plantain marketing in Oshimili South Local Government area of Delta State. The specific objectives are to; describe the socio-economic characteristics of plantain marketers in Oshimili South LGA of Delta State; determine the market activities and functions performed by plantain marketer; analyse the efficiency of plantain marketing: determine the profitability of plantain marketing and identify constraints to efficient plantain marketing.

METHODOLOGY

The study area was Oshimili South Local Government Area in Delta North Agriculture Zone. Oshimili South LGA occupies a total area of 603 square kilometres and has an average rainfall of 1,765mm and temperature of 29°C. It lies off the shores of the River Niger with an average humidity of 84%. Oshimili South LGA is made up of four (4) towns namely: Asaba, Okwe, Oko and Anwai. Plantain marketers for this study were purposively sampled from three (3) out of the four (4) areas namely: Okwe, Oko and Asaba. These Areas have urban and semi-urban population settlements with markets where plantain marketers trade. The plantain marketers sampled were made up of wholesalers and retailers. Fourty (40) plantain marketers were sampled through random sampling techniques from each of the towns selected giving a total of 120 plantain marketer respondents used for the study. Primary data was used for the study. The data was collected through the use of structured questionnaire. The questionnaire was administered to 120 respondents and there was 100% return rate.

Data Analysis

Descriptive statistics was used to analyze the socio-economic characteristics of plantain marketers. Gross Margin was used to determine the marketing of plantain margin as shown below: Marketing Margin= Pf – Pr. Where Pf. = Producer prices, Pr = Retail price. Net profit equation was used to determine the net return of plantain marketers as shown below:

Marketing Margin = Pf -Pr

Where Pf = Producer prices (N)

Pr= Retail Price (N)

Net profit equation was used to determine the net return of plantain marketers as shown below:

Net profit (NP) =Total revenue - Total cost

i.e. = TR - TC

Shepherd-Futrel model was used to analyze the marketing efficiency of plantain in the study area. This is shown below:

Marketing Efficiency Coefficient: Total Cost/Total Revenue X 100/1

The coefficient showed the proportion of total revenue that was put into the marketing cost. The lower the coefficient the more efficient the market and this expressed in percentage.

The factors affecting the efficiency of plantain in the study area were estimated using the multiple regression model. This is as shown below;

$Me = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + U$

Where;

M_e = Marketing Margin

X_1 = Experience, X_2 = Distance, X_3 = Gender, X_4 = Age, X_5 = Education, X_6 = Household Size, X_7 = Quantity Traded, X_8 = Transportation

β_0 = Intercept term, U = error term

RESULTS AND DISCUSSION

The socio-economic Characteristics result shown in Table 1 reveals that 80% of the respondents were female. This finding agreed with the result of Okezie (2017) in which he estimated that 80% of all trades in food stuff in Nigeria is carried out by rural women. The result also reveals that respondent whose age range between 41- 50years have the highest percentage (51.7%) followed by age range of 51-60 years (22.5%). This is an indication that people whose age range is between 41-50 years are more involved in plantain marketing in the study area. This may imply that people of this age range are likely to be more energetic and willing to take risks involved in plantain marketing.

The result further reveals that 57.5% of the respondents are married with their husband/wives still alive. This implies that plantain marketing is a reliable source of income for the upkeep of the family. The result also reveals that a greater percentage (45%) have secondary education. This finding contrasts with Okezie (2017), in which he estimated that most respondents had no formal education. The implication of this could be that plantain marketing is taking care of unemployment as more educated people are getting involved in the business. The household size of the respondents shows that the highest range was between 1- 4 persons (51.7%) and the least as 7persons and above (20%). The result shows that the trend of having large family size which serves as a source of labour is fast disappearing and this is assumed to be due to adverse economic situation in the country.

Table 1: Distribution by Socio-Economic Characteristics

Variables	Frequency	Percentage (%)	Mean
Sex			
Male	24	20	

Female	96	80	Female
Age			
<40 years	12	10	51.6
41-50 years	62	51.7	
51-60 years	27	22.5	
>60 years	19	15.8	
Marital Status			
Single	31	25.8	Married
Married	69	57.5	
Divorced	5	4.2	
Widowed	15	12.5	
Educational level			
Primary	38	31.7	Secondary
Secondary	54	45	
Tertiary	6	5	
No Education	22	18.3	
Household Size			
1-3	34	28.3	4-6 persons
4-6	62	51.7	
7 and above	24	20	
Business Experience			
1-10 years	83	69.2	
11-15 years	21	17.5	1-10 years
16-20 years	10	8.3	
Above 20 years	6	5	

Efficiency of Plantain marketers

The effect of the socio-economic characteristics of plantain marketers on marketing margin showed that several variables entered into the model were statistically significant. An R^2 of 0.786 indicated that 78.6% of the changes in market margin of plantain marketers were determined by the various variables entered in the model. The remaining 21.4% were determined by other variables not included in the model. An F-ratio of 14.04 indicated that the overall regression equation is statistically significant at 1% level.

The variables that had significant effect on the dependent variable (Plantain market margin) include: marketing experience, distance, education, quantity traded and transportation.

i. **Marketing Experience:** Marketing experience with a coefficient of 2719.9 and a t-value of 10.45 which is statistically significant at 1% level. It is also positively related to marketing margin. This therefore implies that and increases in the marketing experience of the plantain marketers ceteris paribus will lead to an increase in the marketing margin.

ii. **Distance:** Distance with a coefficient of 2.28 and a t-value of 1.74 indicated that it is statistically significant at 10% level and is positively related to marketing margin.

iii. **Education:** Education with a coefficient of 707.21 and a t-value of 2.45 is statistically significant at 5% level and positively related to marketing margin which implied that an increase in the educational level of the plantain marketer will lead to an increase in the marketing margin.

iv. **Quantity Traded:** Quantity traded with a coefficient of 538.36 and a t-value of 10.40 is statistically significant at 1% level. It is also positively related to marketing margin. The implication is an that and increase in the quantity traded will lead to an increase in the marketing margin.

v. **Transportation**: Transportation with a coefficient of -0.28 and a t-value of -2.86 was statistically significant at 5% level. However, it is negatively related to the dependent variable (Plantain marketing margin). This implied that as the transportation cost increases the marketing margin decreases. A 1% increase in the transportation cost of plantain will lead to a 0.28% decrease in the marketing margin of plantain.

Table 3. **Efficiency of Plantain Marketers**

	Unstandardized B	**Coefficient Std. Error**	**Unstandardized coefficient Betta**	**T**	**Significance**
Constant	14610.161	987.216		14.799	.000***
Experience	2719.958	260.230	.102	10.452	.000***
Distance	2.281	1.304	.173	1.749	.083*
Gender	224.537	2447.710	.009	.092	.927
Age	170.063	140.775	.111	1.208	.230
Education	707.215	288.187	.229	2.454	0.16**

Household Size	771.429	572.317	.129	1.348	.180
Qty Traded	538.364	51.740	.098	10.406	.000***
Transportation	-.284	.100	-.025	-2.869	.007**

A. Dependent Variable: Marketing Margin
NB:*Significant at 10%, **significant at 5%, ***significant at 1%
Model Summary

Model	R	R Square	Adjusted Square	R Std Error of the Estimate
1	0.887²	0.786	0.627	12.95012

a. Predictors: (Constant), transportation cost, Education, Experience, Age, Qty Traded, Gender, Household Size, Distance.
ANOVA

Model	Sum of Square	Df	Mean Square	F	Sig
Regression	1883307409.406	8	235413426.176	14.037	.002
Residual	18447623683.031	110	167705669.846		
Total	20330931092.437	118			

a. Dependent Variable: Marketing margin
b. Predictors: (Constant), transportation cost, Education, Experience, Age, Qty Traded, Gender, Household Size, Distance.

Profitability of Plantain Marketing
The profitability of plantain marketing in Oshimili South Local Government Area of Delta State was determined by finding out the cost and selling price of bunches of plantain fruit.
The cost and return analysis of one dozen (12) bunches of average sized plantain fruit is presented in the table below.

Table 4: Profitability of Plantain Marketing

Variables	Amount in Naira (₦)	
Revenue from sale of average 12 bunches (Total revenue [TR])	9,362.40	9,362.40
Variable Costs		
I. Cost of Purchase	4,874.50	
II. Transport Cost	520.00	
III.Other Cost	100.00	
Total Variable Cost (TVC)	5,494.50	5,494.50
Gross Margin (GM = TR -TVC)		3,867.90
Return on Investment (ROI) = GM/TC		0.704

Table 4 showed that the average variable cost per dozens of plantain bunches is ₦5,494.50 and the average total revenue per dozens of plantain bunches is N9,362.40. The Gross Margin is ₦3,867.90. The return on investment (ROI) is ₦0.704 showing that for every one naira spent plantain marketers in the study area attract a gain of 70 kobo. It can then be deduced from the above result that plantain marketing is a profitable venture. This is in conformity with the findings of Offor (2019), that plantain marketing is a profitable venture.
Constraints of plantain marketing in the study area.
The constraints militating against plantain marketing is presented in Table 5. High transportation cost with a rating of 37.5% constitute a major constraint to plantain marketing and formed one of the highest proportions of the total marketing cost. This is due to the distance traveled to purchase the product from farmers. Another challenge faced by plantain marketers was rapid deterioration in quality or spoilage with a rating of 15%. There is also poor market accessibility which accounts for about 13.3% of the constraints. Access to credits accounted for 11.7% of the constraints.

Table 5. Distribution of Plantain Marketing constraints

Constraints	Frequency	Percentage (%)
Access to credit loans	14	11.7
Security	7	5.8
Inadequate funds	10	8.3
Market Accessibility	16	13.3
Rapid Deterioration in quality/spoilage	18	15
Seasonal price fluctuation	10	8.3
High Transportation Cost	45	37.5
Total.	120	100

CONCLUSION

The findings of the study revealed that plantain marketing is a perfect competitive market. There is no restriction into the business, and it is profitable with moderate net income. However, there are some constraints such as high transportation cost, rapid spoilage, market accessibility, access to credits, inadequate funds, seasonal price fluctuation and security. Findings also revealed that plantain marketing is a profitable venture in the study area.

Based on these research findings, the following recommendations are made: Problem of infrastructural facilities such as bad roads should be addressed by all tiers of government. Bad road should be reconstructed and new ones constructed especially those that link the rural areas with urban areas. This will help in getting the produce to the market places in good quality. It will bring about a reduction in transportation cost and hence the cost of marketing. The marketers should come together to form plantain marketer's cooperative groups from which members could obtain loans at very low interest rates to finance and expand their business. Proper handling during on-loading and/or off-loading as well as good storage facilities will reduce the rapid deterioration in quality and spoilage of the plantain and thereby increasing profit. Development and adoption of better techniques that will simplify plantain processing to reduce the spoilage of overripe plantain and bring about value addition is require.

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ACCESSIBILITY TO USAID MARKETSII PROJECT AMONG CASSAVA FARMERS IN IBARAPA CENTRAL LOCAL GOVERNMENT AREA OF OYO STATE, NIGERIA

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ABSTRACT

The study analyzed accessibility to USAID MARKETSII project among cassava farmers in Ibarapa Central Local Government Area. A multistage sampling technique was used to select 130 cassava farmers. Structured interview schedule and questionnaire was used to elicit responses from respondents on socioeconomic characteristics, level of accessibility to USAID MARKETSII technologies and constraints faced by participants in accessing MARKETS II package of practice. Data were analyzed using descriptive and inferential statistic at p =0.05. Access to MARKETS II project was more on improved farm inputs (2.70), buyback for MARKETS II cassava (2.66), effective extension service (2.64) and appropriate technology (2.58). Majority (62.3%) had high level of accessibility to MARKETS II Project. Respondents' constraints to MARKETS II project were more on pest and diseases ranked highest (2.23), invasion of cattle into farm land (2.01) and high cost of labour (1.80). A significant relationship existed between constraints (r= -0.459, p<0.05) and respondents' access to USAID MARKETS II project. It is therefore recommended that more effort should be made to make sure that some MARKETS II project that were least accessible (better pesticide management and adequate finance) be made accessible to farmers.

Keywords: *MARKETS II; Accessibility; Project; Invasion*

INTRODUCTION

The Maximizing Agricultural Revenue and Key Enterprise in Targeted Sites (MARKETS II) is USAID/Nigeria's flagship project under their Feed the Future (FTF) Agricultural Transformation Program (ATP) and is a successor to the previous seven years of the MARKETS and the Bridge to MARKETS 2 (BtM2) projects. United States Agency for International Development (USAID) is an international agency that provides foreign aids to needy countries. The agency's intervention in agricultural production is known as Maximizing Agricultural Revenue and Key Enterprises in Targeted Sites (MARKETS). MARKETS is working along the value chain of cassava in order to improve productivity, income, sales, and jobs at firm and farm levels (USAID MARKETS, 2013). USAID MARKETS was initiated in 2005, and designed to expand economic opportunities in Nigeria's agricultural sector. Over time, USAID-MARKETS have grown to provide farmers with assistance such as fertilizer supply and technology development; seed development, and farmers training (USAID, 2013). USAID MARKETS II project was initiated to assist cassava producers with adequate knowledge and skills to enhance cassava productivity, income, and their well-being (USAID-MARKETS, 2014). Cassava (*Manihot esculenta*) is of major economic importance as food crop for approximately 200 million people in sub-Saharan Africa countries, including Nigeria (Afolami *et al.*, 2015). In Nigeria, cassava is a major staple food crop (Ajala *et al.*, 2014). Its root and leaves are valuable and a major source of calories and income for rural households in the country (Afolami *et al.*, 2015). Cassava crop has continued to gain prominence among farmers in Nigeria while the industrial demand is also rising consistently (FAO, 2018). This was further supported by the assertion of Anyeagbunam, *et al*., (2015), that cassava has become a very popular crop in Nigeria and is fast replacing other traditional local staples in the country (Zie *et al*., 2019).

It has been opined that over dependent on traditional technologies by smallholder farmers in Nigeria had continuously subjected them to poor yields and inefficiency (Oyewole and Ojeleye, 2015). Likewise, Nwachukwu (2013) described Nigerian agriculture as being associated with drudgery in which farmers depend heavily on hand-tools in carrying out cultural operations on their farms manually. Hence, MARKETS II technologies through the adoption of best agronomic management practices such as optimal spacing, access to the International Institute of Tropical Agriculture's (IITA's) improved disease-resistant cassava varieties, and the introduction and timely use of NPK, insecticide and herbicide to their fields, etc., is an assured way of progressively maintaining cassava bumper yields. . Nzekwe *et al.* (2015) suggest that regardless of a project's completion time and cost, it can still be considered as failed if the project does not fulfil its required purpose. The potentiality of USAID MARKETS II technologies to enhance greater increase in yield of cassava has necessitated the assessment of accessibility of cassava farmers to USAID MARKETS II technologies in Ibarapa central local government area of Oyo State. This study therefore answered the following research questions; what are the enterprice characteristics of MARKETSII participants in the study area, what is the level of accessibility to USAID MARKETSII technologies in the study area, what are the constraints faced by participants in accessing MARKETS II package of practice in the study area?

METHODOLOGY

The study was carried out at Ibarapa Central Local Government Area of Oyo State, Nigeria. It consists of two towns: Igbo-Ora and Idere. It is located in the Southwest geographical zone of Nigeria with its headquarter in Igbo-Ora. The population of the study were registered MARKETS II Cassava farmers in Ibarapa Central Local Government Area of Oyo State. A multistage sampling procedure was adopted to sample the respondents for this study. The first stage was purposive sampling of Oyo state due to the presence of MARKRTS II**.** There are four ADP zones in Oyo State, the second stage involved random selection of 25% of ADP zones. The third stage involved random selection of 10% of the blocks that participated in MARKETS II project in Ibadan /Ibarapa zones. The fourth stage involved random selection of 30% of the registered farmers from the block which has 432 farmers to give a total of 130 farmers. Data was collected through the use of structured questionnaire and interview schedule. Variables assessed were enterprise characteristics, constraints affecting access to MARKETS II project which was measured using a three-point scale of not a constraint, mild constraint to severe constraint with scores of 0, 1 and 2 assigned, respectively and weighted mean score was calculated in order to ascertain the severity of the constraints. Accessibility to USAID MARKETSII project among cassava farmers was measured on a three point scale of always, sometimes, never and scores of 2, 1 and 0 were assigned respectively. Maximum, minimum and mean score were obtained. The mean score was used to categories respondents into having low or high access. Data was analyzed using descriptive statistics such as frequency counts, percentages, mean scores, while inferential statistics; Pearson Product Moment Correlation (PPMC) was used to analyze study hypothesis.

RESULTS AND DISCUSSION

Enterprise characteristics of Respondents

Result in Table 1 shows that (43.8%) of the respondent earned less than 200,000, (37.8%) of them earned between 200,001-500,000, (11.5%) of them earned between 500,001 – 800,000 while (6.9%) of them earned above 800,001. This implies that the respondents made considerable income annually but still living below $1.90 per day, an indication that they are living below the poverty line. The distribution of mode of land acquisition by the respondents shows that (46.7%) of the respondents acquired the land by renting, (30.0%) of them acquired the land through inheritance and (23.1%) of them got it communally. This indicates that majority of the respondents rented land. This disagrees with the findings of Durojaiye and Ogunjimi (2015) who reported that 64% acquired their land for cassava production through inheritance and the remaining 36% acquired theirs by leasing and renting. The result on cultivated cassava farm size shows that most (91.6%) of the respondents had farm size ranging from 1-10 hectares with mean farm size was 5.45. This finding corroborates with USAID Feed the Future (2017) that through a market-demand value chain orientation, MARKETS 11 focused on the large population of small holders with between1-5 hectares of land under cultivation which makes up the vast majority of all farmland in Nigeria. The Project's systemic approach addressed limitations and opportunities in all of the value chain segments that could have an impact on farmers' food security. Majority of the respondents (94.6%) has less than 10 tonnes output, a few (4.6%) of them had between10-20 output (tonnes) with mean output was 5.40. The study reveals that (33.8%) of the respondents had between 11-15 years of experience in cassava farming. This result is in agreement with the finding of Otubo (2021) who reported his respondents had between 11-20 years of experience in cassava farming. The study reveals (33.1%) of the respondents used hired labour, (23.8%) of them used family and hired labour, (23.1%) of them used self, family and hired labour. This implies that using hired labour is common among respondents. This finding agrees with Abd' Kabir (2021) who reported that most of his respondents (83.75%) used hired labor.

Table 1: Enterprise characteristics of the respondents

Variables	Frequency	Percentage	Mean
Income in Naira			
Less than 200,000	57	43.8	
200,001 – 500,000	49	37.8	
500,001 - 800,000	15	11.5	
Greater than 800,000	9	6.9	
Land Acquisition			
Inherited	39	30.0	
Rent	61	46.9	
Communal land	30	23.1	
Cultivated Cassava Farm Size			
Less than 10 hectares	119	91.6	5.45

10-20 hectares	9	6.9	
Above 20	2	1.5	
Actual output/yield (Tonnes)			
Below 10	123	94.6	5.40
10-20	6	4.6	
Above 20	1	0.8	
Years of experience			
Below 5years	14	10.8	
6-10 years	41	31.5	
11-15 years	44	33.8	
Above 15 years	31	23.9	
Source of labour			
Self	1	0.8	
Hired	43	33.1	
Family	25	19.2	
Family and hired	31	23.8	
Self, family and hired	30	23.1	

Source: Field survey, 2023

Accessibility to MARKETS II project

Table2 shows the respondents' accessibility to MARKETS II project. Based on the weighted mean of variable reported, access to MARKETS II project was more on improved farm inputs (2.70), buyback for MARKETS II cassava (2.66), effective extension service (2.64) and appropriate technology (2.58). This implies that better pesticide management among farmers, buyback for MARKETS II cassava, effective extension service and appropriate technology were available and farmers had access to them. They had least access to better pesticide management among farmers (2.45) and adequate finance (2.37). MARKETS II has the ability to link extension to farmers and input suppliers and also ability to link borrowers with lenders. The least accessible MARKETS II Project were better pesticide management among farmers and adequate finance may be because farmers have constraints in accessing better pesticide management and in obtaining collateral security to obtain finance.

Table 2: Accessibility to MARKETS II Project

MARKETS II Project	Always	Sometimes	Never	WMS	Rank
Adequate finance-	46.9	43.8	9.2	2.37	6th
Appropriate technology	60.8	36.9	2.3	2.58	4th
Better pesticide management practice in MARKET II	50.8	42.3	6.9	2.43	5th
Improved farm input in MARKETS II project	71.5	27.7	0.8	2.70	1st
Effective extension service	66.2	32.3	1.5	2.64	3rd
Buy back for MARKETS II cassava farmers	67.7	31.5	0.8	2.66	2nd

Source: Field survey, 2023 Grand mean =2.56

Categorization of level of accessibility to MARKETS II Project

Table 3 further reveals that 62.3% had high level of accessibility to MARKETS II Project while 37.7% of the respondents had low level of accessibility to MARKETS II Project. This implies that respondents experience relatively high level of accessibility to MARKETS II project in the study area.

Table 3: Level of accessibility to MARKETS II Project

Overall level of accessibility	Frequency	Percentage
Low	49	37.7
High	81	62.3
Total	130	100

Source: Field survey, 2023

Constraints faced by cassava farmers in MARKETS II Project

The respondents' constraints to MARKETS II project were explored using weighted mean score as shown in Table 4.Table 4 shows that pest and diseases ranked highest (2.23) among constraints faced by MARKETS II participants. This corroborates the findings of Ayoade (2012) who ranked problem of pests and diseases as second among the constraints encountered by cassava farmers. Invasion of cattle into farm lands ranked second (2.01), the problem of cattle invasion on farm land could be attributed to insufficient pasture for grazing. High cost of labour ranked third (1.80). Inadequate access to credit ranked fourth(1.68), this implies that respondents have difficulties in accessing credit facilities to engage in productive farming which could be attributed to unavailability of sources of credit to the farmers. This is in line with the findings of Okotie (2018) that despite funding from International agencies, farmers are still faced with difficulty in accessing credit facilities. Insufficient physical inputs needed for production ranked fifth (1.63).Poor accessibility of technology to the farmer ranked sixth (1.63). Transportation challenges ranked seventh (1.56), this negates the findings of Ayoade (2012) who ranked poor transportation as third among the constraints encountered by cassava farmers. Irregular rainfall pattern ranked eight (1.55). Poor result demonstration during training ranked ninth (1.51). Inadequate extension contact ranked tenth (1.43) and the least constraint which is gender inequality in input distribution ranked eleventh (1.30).

Table 4: Constraints faced by cassava farmers in MARKETS II project

Constraints	Not a constraint	Mild constraint	Severe constraint	WMS	Rank
Inadequate access to credit	46.2	40.0	13.8	1.68	4th
Poor accessibility of technology to the farmers	40.8	55.4	3.8	1.63	6th
Invasion of cattle into farm lands	19.2	60.8	20.0	2.01	2nd
High cost of labour	38.5	43.1	18.5	1.80	3rd
Irregular rain fall pattern	53.8	37.7	8.5	1.55	8th
Transportation challenges	57.7	28.5	13.8	1.56	7th
Insufficient physical inputs needed for production	47.7	40.0	12.3	1.65	5th
Poor result demonstration during training	59.2	3.8	10.0	1.51	9th
Pest and diseases	16.2	44.6	39.2	2.23	1st
Gender inequality in input distribution	73.8	22.3	3.8	1.30	11th
Inadequate extension contact	61.5	33.8	4.6	1.43	10th

Source: Field survey, 2023 Grand mean = 1.67 WMS - Weighted mean score

Correlation between respondents' constraints and access to USAID MARKETS II project

The PPMC result in Table 5 reveals there was a negative and significant correlation between respondent's constraints and their access to USAID MARKETS II project ($r= -0.459$, $p<0.05$). This implies that constraints the respondents faced in cassava production influences their access to USAID MARKETS II project.

Table 5: Correlation between respondent constraints and their access to USAID MARKETS II project

Variables	r-value	P-value	Remark
Constraints	-0.459	0.001	S

Source: Data analysis, 2023

CONCLUSION AND RECOMMENDATIONS

The study concludes that access to MARKETS II project was more on improved farm input, buyback for MARKETS II cassava, effective extension service and appropriate technology. Respondents had high level of accessibility to MARKETS II Project. Respondents' constraints to MARKETS II project using weighted mean score and grand mean shows pest and diseases, invasion of cattle into farm lands, high cost of labour and inadequate access to credit as the major constraints faced by cassava farmers in the study area. There was a negative and significant correlation between respondent's constraints and their access to USAID MARKETS II project. It is therefore recommended that more effort should be made to make sure that some MARKETS II project that were least accessible (better pesticide management and adequate finance) be made accessible to farmers. Ways to tackle invasion of cattle into farmland should be looked into.

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ANALYSIS OF ONION MARKETING IN UNGWAGGO LOCAL GOVERNMENT AREA OF KANO STATE, NIGERIA

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ABSTRACT
This study analysis of onion marketing in Ungwaggo Local Government Area, Kano State, Nigeria. The study was conducted through a survey of onion marketers. The specific objectives of the study were to describe the socioeconomic characteristics of onion marketers, determine marketing margins, determine marketing efficiency, and describe the problems of onion marketing in the study area. Data were collected through the use of questionnaire administered on 66 marketers (respondents). Data were analyzed using descriptive statistics such as means and frequency distributions, and marketing margins. The results show that most onion marketers in the study area were married (81.8%). About (39.4%) of them were enrolled in non-formal schools. Marketers earned N3,040 per 120 kg bag as profit, accounting for 24.16% marketing efficiency. The hurdle for marketers was little or insufficient understanding of onion marketing. The study also shows that insufficient storage facilities, poor access to credit, lack of market information and poor transportation hindered effective marketing of onions. The study recommends adequate credit facilities, improved market access and market intelligence, and better access to technical resources to improve onion commercialization.
Keywords: *Onion marketing, marketing margin, marketing efficiency*.

INTRODUCTION
Onion (*Allium cepa*) is a vegetable belonging to the Liliaceae family (Alabi and Adebayo, 2008). Also known as "garden onion" or "onion," it is one of the oldest cultivated vegetables. Tubers grow underground and are used to store energy, which can lead to confusion with non-tuberous tubers (Wikipedia, 2010). The leaves are blue-green and hollow, and the tubers are large, fleshy and firm (Azu *et al.*, 2007). It is sold primarily as a fresh fruit vegetable and plays an important role in the preparation of food in most households. It is effective against colds, heart disease, diabetes, osteoporosis, and coughs and sore throats. They are rich in flavonoids, concentrated in the outer layer of the pulp (Nemeth *et al.*, 2007). Hussaini *et al.*, (2000) identified onions as the second most important vegetable after tomatoes. Onions (Allium cepa) are mainly grown in Nigeria, Niger, Ethiopia, Burkina Faso, and Senegal. The cultivation of this crop has grown steadily in the tropics for more than forty years. The total area under onion cultivation in the world doubled to 2.74 million hectares (Pelter *et al.*, 1992; FAO, 2002). In agriculture, horticultural crops, including onions, occupy an important place. Marketing typically begins on the farm when farmers harvest their produce. It is a common issue that the goods, once gathered, are unable to reach their intended purchasers. Harvested products are rarely in a form that is suitable for consumption and must be cleaned, sorted, processed and presented in appropriate amounts and quality for sale to consumers (Asogwa and Okwoche, 2012). Therefore, marketing encompasses all aspects of business operations, including production and the involvement of intermediaries, until the product reaches the end consumer.

Research on food marketing has revealed a direct and causal relationship between the structure of the industry and market conduct. According to Anuebunwa *et al.*, (2006), there exists a causal correlation between the structure of a market and its performance, which can be defined as deterministic in nature. This relationship is influenced by the actions and behaviour of market participants and can be observed through the outcomes and results of the market's operations. When comparing its trade value to that of other produce, such as tomatoes and peppers, the onion (*Allium cepa*) holds its own. It is a crop that garners attention in the market due to its distinct status as a frequently utilized vegetable in virtually every household, as stated by (Dogondaji *et al.*, 2006). Despite the numerous potential benefits of onions in medicine, economics, and industry, there has been no serious marketing studies conducted on this vegetable in the study area. The marketing of crops in Eastern Nigeria is a subject that varies widely depending on the region. However, it is generally understood that marketing strategies for crops are diverse and influenced by factors such as location, infrastructure, and access to markets.The broad objective of this study was the analysis of onion marketing in Ungogo Local Government Area of Kano State, Nigeria. The specific objectives were to: describe the socio- economic characteristics of the onion marketers, determine the marketing margin of the onion and describe the problems of onion marketing in the study area.

METHODOLOGY

The study was conducted in Ungwaggo Local Government Area of Kano State, Nigeria. Ungwaggo local government is one of forty-four local government areas of Kano state. Its headquarters is in *Ungwaggo* town, Two stage sampling techniques were used; these were purposive and simple random sampling in selecting a representative sample of onion marketers in the study area. Ungwaggo local government area was selected for this study because onions were highly marketed in the area. There are eleven (11) wards in Ungwaggo local government area namely; Bachirawa, Gayawa, Kadawa,Karo, Panisau, Rangaza, Rijiyar Zaki, Tudun Fulani, Ungogo, Yadakunya and Zango. Four (4) wards were purposively selected due to the concentration in marketing of onions and 66 respondents were randomly selected from the four wards which include Bachirawa market, Gayawa, Kadawa and Rijiyar Zaki respectively. From each ward in the study area, thirty-six (36) marketers were selected in Bachirawa market due to the higher number of marketers, thirteen (13) respondents in Gayawa, Nine (9) respondents in Kadawa, Eight (8) respondents in Rijiyar Zaki. The analytical tools used were, descriptive statistics and marketing margin. Primary data were used for this study. The primary data were collected with aid of structured questionnaire which was administered on the onion marketers (respondents) in the study area.

RESULTS AND DISCUSSION

Majority in table 1. of onions marketers were youth with mean age of 40 which implies that they were economically active, 93.9% of the respondents were male and 6.1% were female, both male and female were involved but female did not participate in the open market rather they participated in their houses as result of religion and culture of people in the study area. About 81.8% of the respondents were married and 18.2% were single, formal education was generally low whereas most of the respondents attended informal schools in the study area. About 31.82% of the onion marketers fell between 1 to 10 years of experience, majority of onion marketers had household size ranging from 1-5, (53.03%). Table 2. Shows that marketers earned ₦ 3040 per 120 kg bag, Marketing efficiency of onion marketing was 24.16%, meaning that there was high marketing efficiency in the onion marketing in the study. Table 3. Shows the Constraints of onion marketing with 25.23% of the respondents faced inadequate credit facilities which rank first, followed by inadequate storage facilities having 19.16%, Transportation problem having 15.42%, Onion being a highly perishable farm produce, needs to be stored properly to minimize losses due to deterioration in quality. Marketers in some cases suffer losses of between 50% -70% due to inadequate storage facilities. price fluctuation faced 24.30% and 15.89% faced inadequate recent information respectively. This result implied that majority of problem faced of the onion marketers in the study area were inadequate credit facilities. Ungwaggo being a Local Government Area needs to be served by functional transport facilities such as lorries to facilitate easy and timely movement of onion into the State capital. Where the means of transportation are not readily available as is mostly the case, marketers are forced to sell their onion below the market value, as the gloat in the market pull down the price of onion to their disadvantage or stand the risk of losing their investment because lack conventional storing facilities. These problems have adverse effects on the marketer's profit by causing damage due to inadequate storage facilities and increased marketing cost due to inadequate transportation facilities.

Furthermore, lack of capital and credit facilities have effect on the size of marketers holding as well as their marketing scope.

Table 1: Socio-economic characteristics of respondents

Characteristics	Frequency	Percentage	Mean
Age			
<20			
21-30	17	25.77	
31-40	21	31.82	
41- 50	15	22.73	40
51-60	10	15.15	
61-70	3	4.55	
Sex			
Male	62	93.9	
Female	4	6.1	
Occupation			
Civil servant	21	28.0	
Public Servant	18	24.0	
Artisan	3	4.0	
Student	12	16.0	
Unemployed	21	28.0	
Educational Qualification			
No formal education	26	39.4	
Primary education	10	15.2	
Secondary education	22	33.3	
Tertiary education	8	12.1	

Marital status			
Married	54	81.8	
Single	12	8.2	
Household Size			
1-5	35	53.03	6
6-10	26	39.39	
11-15	5	7.58	
Years of Experience			
1-10	21	31.82	
11-20	20	30.30	19
21-30	10	15.15	
31-40	9	13.64	
41 and above	6	9.09	
Total	66	100.0	

Source: Field survey, 2019

Table 2: Marketing margin of onion in the study area

Items	**Cost (₦)**
A) **Selling Price**	**12,500**
B) Marketing cost120 kg bag of Onion	8500
Transportation	250
Loading	100
Offloading	100
Cleaning and Sorting	200
Storage	50
Tax	10
Packaging	250
Total Marketing cost	**9,460**
D) (Selling price– marketing cost)	**3040**
Marketing Margin	**24.32%.**

Table 3; Distribution of the respondents according to constraints

Constraints of onion marketing	**Frequency***	**Percentage**	**Ranking**
Inadequate credit facilities	54	25.23	1st
Price fluctuation	52	24.30	2nd
Inadequate storage facilities	41	19.16	3rd
Inadequate recent information on profitability	34	15.89	4th
Problems of transportation	33	15.42	5th
Total	214	100	

Source; Field survey 2019; *Multiple response

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

i. Marketing loans and credit should be made available to marketers at a low interest rate to help them finance their marketing activity.

ii. To overcome the problem of price fluctuations, the private sector should be encouraged to establish onion dehydration plants to process the onion into more durable product. This may help to enhance the year-round availability of the commodity in addition to preparing it for export.

iii. Transport facilities should be provided either through cooperative efforts or by Government to link the farms with the market as well as the Local Government Area with the state capital to help reduce marketing costs as well as increase marketers' profit.

iv. Adequate and conventional storage facilities should be made available in the market by the government to counteract the problem inadequate storage facilities.

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EFFECT OF COVID-19 PANDEMIC ON RICE FARMERS PRODUCTIVITY IN IHITTE/UBOMA L.G.A, IMO STATE

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ABSTRACT

The study analyzes the effect of COVID-19 pandemic on rice farmers in Ihitte/Uboma L.G.A. The objective of the study was to examine the socio-economic characteristics of rice farmers, ascertain the extent to which COVID-19 has affected rice farming productivity, to determine the constraints faced by rice farmers during the COVID-19 lockdown. Simple random sampling technique was used in selecting a total number of sixty respondents. Data was collected with a well-structured questionnaire and was analyzed using descriptive statistics, Heckman two step selection model and Likert 5 scale. The result showed that majority of respondents were males (96.7%), most of the farmers were between 51 – 60 years in age (50%) and those that attended secondary education (61.6%). Heckman two steps selection model result shows that farm size was found to be significant at 1% and has a positive influence on the extent of rice production during the COVID-19 lockdown. The likert 5 scale result shows that high cost of input, lack of access to input and decrease in demand for rice were the major challenges during the COVID-19 lockdown with a percentage of 4.683333%, 4.283333% and 3.066667% respectively. The research reveals that the COVID-19 pandemic affected the rice farmers in the study area which was due to the fact that there was high cost of farm input, lack of access to the market due to no movement / downsizing policy by the federal government. The study recommends that rice farmers should make use of farm machines so as to ease up the workload of their farms and increase their farm size, this will encourage productivity of rice. The government should subsidize the cost of farm inputs such as fertilizers, insecticides etc. so as to enable rice farmers get these farm inputs at affordable prices.
Keyword: *COVID-19, Rice Farmers, Productivity, Agriculture*

INTRODUCTION

The World Health Organization (WHO) pronounced Covid-19 as a pandemic on March 11, 2020 (Congressional Research Service, 2020). The disease outbreak rapidly spread to all part of the world. The COVID-19 epidemic terrified countries into sudden disruption and successfully put businesses at lockdown. It affected living and all profitable activities particularly business enterprises as well as manufacturing firms (Sansa, 2020 and Ruiz Estrada *et al.,* 2020). Manufacturing firms were heavily affected by the COVID-19 pandemic, due to the closures and reduced working hours recommended to curb the spread of the virus; the covid-19 pandemic had a significant negative impact on manufacturing firm. (IOM, 2020).

Corona virus is a contagious disease caused by severe acute respiratory syndrome corona virus. The first known case was identified in Wuhan, China, in December 2019. The disease had since spread worldwide, leading to an ongoing pandemic Zimmer, *(2021).* Symptoms of COVID-19 often include fever, cough, headache, fatigue, breathing difficulties, and loss of smell and taste. A study by researchers at the University of Southern California found that fever may be the first symptoms followed by cough and muscle pain. After these, those infected with the virus will likely experience nausea, vomiting or diarrhea. These develop first, followed by respiratory symptoms possibly a day later. At least a third of people who were infected don't develop noticeable symptoms. Those people who developed symptoms noticeable enough to be classed as patients, 81% develop mild to moderate symptoms (up to mild pneumonia), while 14% develop severe symptoms (dyspnea, hypoxia, or more than 50% lung involvement on imaging), and 5% suffer critical symptoms (respiratory failure, shock, or multi organ dysfunction). Older people are at a higher risk of developing severe symptoms. COVID-19 transmits when people breathe in air contaminated by the corona virus and small airborne particles. The risk of breathing these particles in is highest when people are in close proximity, but they can be inhaled over longer distances, when people are particularly in door. Transmission can also occur if splashed or sprayed with contaminated fluids, in the eyes, nose or mouth and rarely via contaminated surfaces. People remain contagious for up to 20 days, and can spread the virus even if they do not develop any symptoms (CDC, 2019).

Agriculture is a key sector of the economy in many developing countries and remains the basis of any development strategy. It provides employment for about two-thirds of the continent's working population and for each country, it contributes an average of 30% to 60% of their gross domestic product and about 30% of the value of exports (World Bank, 2020). Agriculture can help reduce poverty, raise incomes and improve food security for 80% of the world's poor, who live in rural areas and work mainly in farm. Agricultural development is one of the most powerful tools to end extreme poverty, boost shared prosperity and feed a projected 9.7 billion people by 2050 (World Bank, 2020). It can therefore contribute towards sustainable development goals and major continental priorities, such as eradicating poverty and hunger, boosting intra-Africa trade and investments, rapid industrialization and economic diversification, sustainable resource and environmental management, and creating jobs, human security and food security. Food a major product of farming and it is important for good health and can help fight diseases. In the agricultural sector, cereal production especially rice, wheat and maize have become essential to food security as they provide more than 60% of daily calorie in developing countries (Mckevith, 2004). The place of diet in good health development is one of the major policy concerns and individual dietary intake and can account for the level of development of the Nation. Rice a major cereal is essential in increasing per calories requirement for the health growth in Nigeria.

Rice is an important staple crop that plays an important economic role and feeds approximately half the world's population (Fahad *et al.,* 2019). Rice represents the staple food for more than 750 million people in Sub-Saharan Africa (USDA, 2018). Rice consumption in Africa is growing faster than other food Staples in every part of the World. However, local rice production in Africa and Nigeria in particular has not kept pace with the increase in demand and the gap is being filled through production of other alternatives whose characteristics are more preferred by consumers (Demont *et al.,* 2013). These renders Africa very vulnerable to international trade disruptions such as the ones currently inflicted by the corona virus disease (COVID-19) crisis (Arouna *et al.,* 2020).

The impact of COVID-19 on agriculture is devastating, complex and varied across diverse segments that form the agricultural value chain. This impact will reverberate across the larger economy and will linger unabatedly than few months. Commercial crops are drastically hit as they tend to be more dependent on farmers who are faced with social distancing, quarantine and lockdown. The Shortage of farmers due to COVID – 19 pandemic has resulted in a sharp increase in daily wages for harvesting crops. In several areas, the rise is as high as 50%, making it un-remunerative for the produce since prices have collapsed due to either lack of market access including the stoppage of transportation and closure of borders. COVID-19 pandemic seems to escalate the already existing food security giving the additional impact it has on both production and marketing segment of rice value chain.

However, as the COVID-19 continues to wreak havoc on many countries and create lots of changes in people's livelihood all over the world, the broader economic crisis is also emerging and creating major challenges to food security and nutrition. Many of the affected countries have implemented a regional lockout policy. This strategy enforced a plethora of COVID-19 security measures such as movement control, as well as supermarket, restaurant and market closure, others are quarantines, supply chain and trade disruption which greatly affected agricultural production, food supply and demand. This study aimed to assess the effect of the COVID-19 pandemic on all rice farmers' productivity in Ihitte/uboma LGA, Imo State. This study established policy dissection in case of future pandemic and suggest way out for farmers who may be trapped in the sudden and harsh security measures that were set-up to arrest the spread of the disease in Nigeria and Imo State in particular. The objectives of this study include to determine the socio economic characteristics of rice farmers in Ihitte/uboma LGA, to ascertain the factors to which COVID-19 has affected rice farming productivity in Ihitte/uboma LGA, Imo State, to determine the constraints rice farmers faced during the period of the pandemic in Ihitte/uboma.

MATERIALS AND METHODS

Ihitte/ Oboma is an Imo State local government area in Nigeria. Its headquarters is located In Isinweke . It has a land area of 104 km^2 and a population of 120,744 people, according to 2006 Census. The postal area's code is 472. Towns and villages in Ihitte/uboma include Amakoha (Amuzu, Ipinweke, Nnacheru, Umuokoroezuka, Umuonyeche, Umuoye). Umue-Zegwu(Umuakpi, Umudibia, Umule/Umuhere, Umuode, Umuokparaka). Ato-Werem (Elugwu, Omuchienta, Umuezina, Umulemaku Umuezea Umuopi). Ikper-Ejere (Umuanyaku, Umudwu, Umuchie, Umuejere, Umuzealaduzuk, Umuoppara-Owerre, Umuehie). Umuihi (Dikenachieze, Emekengwe, Ikenafo, Uhebgu, Uhuanwuse, Umudiaba) etc. Due to the dominance of rice farmers in the study area, a purposive sampling method was adopted to select 6 communities from the study area due to the dominance of rice farmers in the communities. Then a Simple random technique was used to select 60 respondents for the study. 10 rice farmers from each of the communities. The data used in this study were predominantly gotten through primary and secondary data source. The secondary data were gotten from existing literatures, publications, textbooks, journals, and internet. The primary data were gotten from the respondents through the use of structured questionnaire. The data collected were analyzed with the use of descriptive statistic method, Heckman two step and Likert scale.

RESULTS AND DISCUSSION

Table 1 – Socio Economic Characteristics of Respondents

Household size	Frequency	Percentage
1 – 3	2	3.3
4 – 6	33	55
7 – 9	23	38.3

10 and above	2	3.3
Educational Level		
1 – 6	22	36.7
7 – 12	37	61.7
13 – 17	1	1.7
Gender		
Male	58	96.7
Female	2	3.3
Age		
21 – 30	0	0
31 – 40	5	8.3
41 – 50	16	26.7
51 – 60	30	50
61 and above	9	15
Farm Size		
0.1 – 1	13	21.7
1.1 – 2	36	60
2.1 - 3	5	8.3
3.1 – 4	5	8.3
4.1 and above	1	1.7
Farming Experience		
1 – 10	4	6.7
11 – 20	35	58.3
21 – 30	16	26.7
31 - 40	5	8.3
Total	60	100

Source: Field survey data 2022

Table 1 shows that a percentage of (55%) of the respondents had family size of 4-6 members, 38.4% of respondents had family size of 7-9 persons. This is good because farmers with large number size of household members tend to be positive for Agricultural productivity since more hands are needed to increase production. 61.6% of respondents spent 7-12 years in school, which is secondary education while 35% spent 1-6 years in school, which is primary education. This simply implies that secondary school, rice farmers have enough skill to increase productivity and rice farming is a business that doesn't really require certificate to run. 96.7% of the respondents are males while 3.3% are females. This implies that rice of farming in Ihitte/Uboma is dominated by males. Majority of the rice farmers (50%) are between the ages of 51-60, 26.6% of rice farmers are between the ages of 41-50 years. This simply implies that rice farming in Ihitte/Uboma is predominant with matured or middle-aged people who are active individuals. Majority of the rice farmers (60%) has between the farm size of 1.1-2, 21.7% of rice farmers has between 0.1-1of the farm size. The farm size can affect the total output of production and income of farmers. 58.3% of farmers have rice farming experience of between 11-20 years, followed by 26.7% with farming experience of between 21-30 years. This implies that majority of rice farmers have more years of experience.

Table – 2 Result of Heckman two Steps Selection Model on the Extent to Which Covis-19 Affected Rice Farmers Productivity.

VARIABLE	COEF	STD ERR	Z	P>Z
Household X_1	-205.3778	156.511	-1.31	0.189
Edu level X_2	140.5232	91.99887	1.54	0.127
Gender X_3	-3010.579	2227.188	-1.35	0.176
Marital stat X_4	1392.681	3031807	0.46	0.646
Age X_5	-29.6920	51.08918	-0.58	0.561
Farm Size X_6	1933.788	309.082	6.26**	0.00
Farming exp X_7	17.9066	48.6310	0.37	0.713
CONSTATNT	6834.66	5575.959	1.23	0.22

ρ	0	Number of obs	=	60
$\sum$	0	Censored obs	=	59
λ	2098.506	uncensored	=	1
waid χ^2	54.3	pro> χ^2	=	0.00

Source: Field survey data 2022 *Significant @ 5% level, **significant @ 1% level.

Table 2 shows that **Farm size (X_6)**: Farm size was found to be significant at 1% level and has a positive influence on the extent of rice production during COVID - 19 Pandemic. This implies that an increase in farm size increases the extent of rice production in the study area during the COVID - 19 pandemic.

Table 3 Result of Likert 5 scale on the constraints faced by rice farmers during covid-19 period

Constraints faced by farmers	SA	A	N	D	SD	MEAN SCORE	RANK
Lack of labour	14		3	16	15	2.1	8
Lack of access of inputs	29	25	1	4	1	4.2	2
High cost of inputs	49	8	0	1	2	4.7	1
Lack of rice processing mills	1	1	14	5	39	1.7	11
Spoilage of rice produce	0	6	20	7	27	2.1	9
Decrease in demand for rice	14	15	6	11	14	3.1	3
Lack of transportation	14	1	19	7	19	2.7	5
International trade disruption	0	0	41	1	18	2.4	6
Lack of spoilage facility	4	3	21	2	30	2.2	7
Reduction of farm revenue	12	11	15	10	12	3.0	4
Confiscation of goods by law Enforcement agencies	0	0	26	0	34	1.9	10

Source: Field survey data 2022

Table 3 shows the Result of Lirkert 5 Scale on the constraints rice farmers faced During the Pandemic, from the analysis above it is clear that high cost of input was the most pressing major constraints during the covid-19/lockdown faced by rice farmer in the study area, lack of access to input followed as a major constraint, Decrease in demand for rice followed as a major constraint, this implies that the revenue of rice farmers was affected negatively. Reduction of farm revenue followed due to low sales caused by decrease in demand of rice produce during the period. lack of transportation was another major problem because of ban on movement during the lockdown, followed by international trade disruption and the least is lack of rice processing mills.

CONCLUSION

This research reveals that the covid-19 pandemic affected the rice farmers in the study area. And this is due to the fact that there was high cost of farm input, lack of access to the market due to no movement/downsizing policy by the federal government and decrease in the demand of rice, as people were restricted in carrying out their daily business activities it led to shortage/decrease of money to spend on food which rice is not exempted. It is recommended that 1. Rice farmers should make use of farm machines so as to ease up the workload of their farms and increase their farm size, this will encourage productivity of rice productivity. 2. The Government should subsidize the cost of farm inputs such as fertilizers, insecticides etc. so as to enable rice farmers get these farm inputs at affordable prices 3. The Government should make an exemption for agricultural produce for easy access and transportation most especially for staple foods such as rice etc., if at all any incident that will warrant closures of markets and movement of citizens re-occurs.

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ANALYSIS OF THE PROFITABILITY OF POULTRY ENTERPRISES IN ABIA STATE

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ABSTRACT
The study assessed the costs and returns of poultry entrepreneurs in Abia State, Nigeria. Primary data were collected with the aid of a questionnaire from 120 poultry farmers selected using multistage sampling techniques. The data were analyzed using the profit function and simple descriptive tools like tables, and percentages. Results revealed that 63% of the respondents were male with a significant proportion (72%) married with a household size of 1-5 persons. The majority (72 %) of the farmers had one form of education or the other. About 13% of the poultry entrepreneurs engaged in breeding/hatchery and day-old chicks' distribution (Br/H/D), 16% engaged in production, live-bird/egg trading, processing, and transportation (P/L/E/Pr/T), 21% engaged in feed milling and transportation (Fm/T), 21% engaged in feed milling, production, processing and transportation (Fm/P/, Pr/T) while 29% engaged in processing and barbeques (Pr/B). The results of the profitability/cost and returns analysis of various poultry value chain activities revealed that operators that combined Br/H/D had ₦ 5000 as net profit, P/ L/E/ Pr/T had ₦ 7000 as net profit, Fm/ T had ₦ 6000 as net profit, Fm/ P/Pr/T had ₦ 9000 as net profit and operators that combined Pr/B had ₦ 4000. The value given was based on a single unit of commodity and not the entire system. Poultry operators in the study area were seen to be profitable and operators that combine feed milling, production, processing, and transportation had the highest net profit of ₦9,000 followed by ₦7,000 for a combination of production, live bird/egg trading, processing, and transportation, the least was ₦4000 for processing and barbeque operators. It is thus; recommended that poultry farmers be encouraged to join FM/P/Pr/T because of its high returns if they want to engage in poultry-related businesses. Age of farmer, sex, educational status, experience, household size, operating expenses, cost of feed, and membership in cooperative society were the factors influencing the profitability of poultry production in the study area
***Keywords**: Poultry entrepreneurs, profitability, transportation*

INTRODUCTION
Livestock production constitutes an essential part of the agricultural economy of Nigeria, It provides meat, clothing, fuel, fertilizer, and draught power to sustain the economy and also serves as additional income earning activities to small and marginal farm families. (Yusuf and Olorunwa, 2018). According to Ekunwe and Soniregun (2007), Poultry production is the management of birds for food, income, and other purposes. It has incredible potential for expanding protein supply in Nigeria and plays a significant role among the livestock-based vocations, this is because of its enormous potential to bring about rapid economic growth and quick returns to investment. Apart from supplying protein, poultry is also a good source of lipids and vitamins of high zoological value to man (Bamiro. 2006). Available information shows that Nigeria hosts more than 45% of the poultry in the West African sub-region and its poultry population is estimated at 140-160 million comprising 72.4 million chickens, 11.8 million ducks, 4.7million guinea fowl, 15.2 million pigeons, and 2 million turkeys (Ebukiba and Anthony, 2016). The demand for poultry products is progressively increasing in as meat consumers' preference for white meat arises. High cost and poor quality of feeds, inadequate finance, poor access to credit facilities, high rate of disease infestations, and high cost of drugs and vaccines are some of the constraints to the growth and profitability of poultry enterprises in the country (Emokaro and Erhabor, 2014; Mamman, 2016; Ebukiba and Anthony, 2019). Therefore, this study seeks to evaluate the profitability of poultry enterprises in Abia State, Nigeria. Specifically, it sought to describe the socio-economic characteristics of poultry farmers and estimate the cost and returns of poultry value chain activities of the entrepreneurs in the study area

METHODOLOGY
This research was conducted in Abia State, the Southeast geopolitical zone of Nigeria. Primary and secondary data were employed in this investigation. A well-structured questionnaire was used to extract primary data from 120 poultry operators in the study area. Secondary data were collected from yearbooks, magazines, journals, and work downloaded from the internet. The multi-stage sampling procedure was adopted in this study. The first stage involved the purposive selection of

three Local Governments Areas (LGA) with relatively high involvement in poultry and poultry-related activities. Ikwuano, Bende, and Aba South were chosen from Umuahia, Ohafia, and Aba respectively. The second stage involves a random selection of 40 operators from the list of poultry operators in the selected LGAs. Thus, the sample size of the study is 120 respondents.

Method of data analysis

Data were analyzed using the profit function. The profit function is given as:

Π = TR – TC

Where:

Π = Profit

TR = Total Revenue

TC = Total Cost =TVC +TFC

RESULTS AND DISCUSSION

Socio-economic characteristics of the respondents

The result on the socio-economic characteristics of the respondents revealed that the majority of the poultry entrepreneurs in Abia state are married men in their active years with a form of education and experience in the poultry business. Table 1 indicates that the majority (48%) of the respondents were within 40-49 years, 28% were between 20-39 years and 23% were more than 50 years, implying that the poultry farmers were within their economically productive age. The result revealed that 63% of the respondents were male with a significant proportion (72%) married. The Table further indicates that 71% of the respondents had a household size of 1-5 members; implying that poultry entrepreneurs would require hired labor (other than relying on family labor) for poultry activities. A vast majority of poultry farmers in the state were educated and experienced in the poultry business. A notable share of the respondents (46%) had secondary education, 29% had primary education, 13% had tertiary education, and 13% had no formal education. The Table shows that 37% of the respondents had work experience of 6 to 10 years. This implies that the poultry farmers were well-groomed and experienced in their business. A significant proportion of poultry operators (63%) were members of cooperatives.

Distribution of poultry value chain combined activities carried out in the study area

Poultry entrepreneurs in Abia state have a combination of value chain activities, Table 2 presents the distribution of poultry value chain combined activities in the study area. The value chain activities identified include Breeding, Hatchery, and Day old Chick Distribution (Br/H/D); Production, Live-bird/egg Trading Processing and Transportation (P/L/E/Pr/T); Feed milling and Transportation (Fm/ T); Feed milling, Production, Processing and Transportation (Fm/P/Pr/T) and Processing and Barbeque (Pr/B). The percentage of entrepreneurs involved in the value chain activities are 13%, 16%, 21%, 21%, and 29% respectively. It implies that operators who combined only the processing and preparation of chicken barbeque were the highest. Br/H /D was done by few operators because of the associated risks in breeding which therefore required the services of experts.

Cost and Return Analysis Results for various poultry value chain activities

Poultry production is a profitable business in the study area. The cost and returns analysis of the respondents is presented in Table **3.** The Table revealed that operators that combined Br/H/D, P/L/E/Pr/T, Fm/T, Fm/P/Pr/T, and Pr/B had ₦5,000, ₦7,000, ₦6,000, ₦9,000, and ₦4,000 net profit respectively (the value given was based on a single unit of commodity and not the entire system). Fm/ P/ Pr,/T had the highest net profit (₦9,000) followed by P/ L/E/ Pr, (₦7,000),the least was (₦4000) for Pr,/B

Table 1; Socio-economic characteristics of poultry operators

Age (Years)	Percentage
20 – 39	29
40 – 59	63
60 – above	8
Total	100
Sex	
Female	37
Male	63
Total	100
Marital status	
Single	17
Married	72
Divorced	11
Total	100
Household size	
1 - 5	71
6 – 10	26
11 – above	3
Total	100
Education	
No formal	13
Primary	29
Secondary	46
Tertiary	13
Total	100

Cooperative membership	
Yes	63
No	37
Total	100
Years of experience	
1 – 5	15
6 – 10	37
11 – 15	29
21 – 25	6
Total	100

Source: Field survey, 2016

Table 2: Distribution of poultry value chain combined activities carried out in Abia state

Activities	Percentage
Br/H, D	13
P, L/E, Pr, T	16
Fm, T	21
Fm, P, Pr, T	21
Pr, B	29
Total	100

Source; filed quarter, yearly survey, 2016

Note: Br/H Breeding/Hatchery, D = Day old chick distribution, P = Production, L/E = Live bird/Egg trading, Pr = Processing, T = Transportation, Fm = Feed milling, B = Barbeque

Table3; Cost and Return Associated to various poultry value chain activities

Item	Br/H/D	P/L/E/Pr/T	FM/T	FM/ P/Pr/T	Pr/B
Average cost price (₦)	18,000	20,000	10,000	25,000	7,000
Average selling price (₦)	21,000	27,000	14,000	30,000	10,000
Average total variable cost (₦)	15,000	17,000	7,000	20,000	7,000
Average total fixed cost (₦)	7,000	8,000	6,000	11,000	4,000
Average return from the sale (₦)	27,000	32,000	19,000	40,000	15,000
Average total cost (₦)	22,000	25,000	13,000	31,000	11,000
Average net returns (₦)	5,000	7,000	6,000	9,000	4,000

Source: Field survey,2016

CONCLUSION

Entrepreneurs that combined processing and preparation of chicken barbeque were the highest while Breeding/Hatchery and distribution of day-old chicks distribution were done by few operators because of the associated risks in breeding which therefore required the services of experts. This research also revealed that poultry and poultry-associated activities in the study are profitable. operators that combine Feed milling, Production, Processing, and Transportation (Fm/P/Pr/T) had the highest net profit of ₦9,000 followed by ₦7,000 for a combination of production, live bird/egg trading, processing, and transportation (P/L/E/Pr/T), the least was ₦4000 for processing and barbeque (Pr/B) operators. It is recommended that poultry farmers be encouraged to join Feed milling, Production, Processing, and Transportation (FM/P/Pr/T) because of its high profitability returns if they want to engage in poultry and poultry-related businesses.

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PROFITABILITY OF TAPIOCA 'ABACHA' PROCESSING IN SOUTH EAST, NIGERIA

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ABSTRACT
Profitability of abacha processing in South East, Nigeria was studied using 120 sampled processors. Structured questionnaire was used to collect primary data. Percentage responses and Net farm income were used to address the objectives of the study. The result of data showed that abacha processing was profitable in the study area with Net Farm Income of N36,800.and return on investment of 0.49. Also, the major constraints to abacha processing were; poor access to credit, high cost of cassava roots, drying method and high cost of labour. The need to enhance processors' access to credit, labour saving devices and drying machines were recommended.
Keyword: *Profitability, Tapioca 'Abacha', Processing, South East, Nigeria.*

INTRODUCTION
Cassava is the basic staple food for more than 70% of the Nigerian population, particularly in North Central, South East, South South and South West, Nigeria (food and Agriculture Organization, (FAO),2017). Cassava can be processed into varied forms. However, the form in which cassava is processed depends on cultural food habits, tastes and preference of the people as well as the variety of cassava and age at harvest of roots (International Institute for Tropical Africa (IITA, 2014). In South East, Nigeria, abacha is amongst the commonest form cassava roots can be processed into (Nweke, Ngoram, Dixon, Ugwu and Ajobo, 2001). Abacha may be consumed with coconut and with sauce for taste According to Alinnor, (2002) abacha can be processed by washing of cassava roots – peeling - boiling for 20 minutes - shredding - soaking of the shredded cassava in water for 12-24hours - water will be changed for about 2-3 times during the period. These processing technology according to Ume, et al; (2020).was disseminated to processors for onward adoption through extension arm of Agricultural Development Programme in the States concerned. The abacha processing has encountered lots of problems that affect its productivity negative. IITA, (2014) enumerated the problems to include, high price of cassava roots, irregular / seasonal supply of cassava roots, low price of abacha, high cost of sieving baskets, water scarcity and high cost of firewood. Therefore, there is need to assess the processors' productivity in terms of profit accruing from the processing in the study area. This could aid in formulation and implementation of policies that would propel the processors to improve on their productivity and among others. Specifically, the objectives of the study were to determine the profitability and constraints to abacha processing in the study area.

MATERIALS AND METHODS
The study was conducted in South east of Nigeria. The zone lies between 5 9'and 7 75'N of equator and longitude 6 85' and 8 46' East of Greenwich meridian time. .It has a population of 16,381.729 people (NPC, 2006)and total land area of 10952400 hectare. It comprises of five states; Imo, Anambra, Ebonyi, Abia and Enugu. Four states (Enugu, Abia, Imo and Anambra) were purposively chosen based on intensity of 'abacha' processing. Multi stage sampling technique was employed in selecting 30 processors from each State, making a total of 120 respondents. The primary data for the study was obtained using questionnaire and oral interview schedules Percentage responses and net farm income were used to capture the processors' profitability and constraints to the processing in the study area.

Model Specification
Gross Margin Analysis Model
Gross margin analysis is the difference between the total revenue (TR) and the total variable cost (TVC)

G.M. = TR – TVC…………………………….……(1)

i.e.G.M= $\sum_{1-1}^{n} P_1 Q_1 - \sum_{j-i}^{m} r_i x_i$ ....(2)

The net farm income can be calculated by gross margin less fixed input. The net farm income can be expressed as thus:

NFI = $\sum_{1-1}^{n} P_1 Q_1 - \left[\left(\sum_{j-i}^{m} r_i x_i \right) + k \right]$ ....(3)

Where: GM = Gross margin (₦), NFI = Net farm income (₦), P1 = Market (unit) price of output (₦), Q = Quantity of output (kg), ri = Unit price of the variable input (kg), xi = quantity of the variable input (kg), K = Annual fixed cost (depreciation) (₦), i = 1 2 3 …….. n , j = 1 2 3 ……m

RESULTS AND DISCUSSION

Table 1 Costs and return of processing 1000kg of cassava roots to tapioca "abacha"

Item	Unit	Price/ unit	Quantity	Value
Revenue				
Tapioca "Abacha"	Kg	300	250	75,000
Total Revenue				75,000
Variable Cost				
Inputs				
Cassava tuber	Kg	30	1000	30,000.
Transportation and firewood				2400
Sub Total				32,400
Labour for the various ·processing operations for tapioca product ion				4,200
Total Variable Cost				36,600
Fixed Cost				1,600
Total Fixed Cost				1,600
Total Cost				38,200
Net return				36,800
Return on investment				0.49

Source; Field Survey, 2022.

Table 1 show that 250kg of tapioca was produced from processing of 1000kg of cassava roots. A kilogram of tapioca was sold at N300 and for 250 kg, a total revenue of N75,000 was obtained. The total cost consists of total variable cost and total fixed cost was N38,200. The cost of inputs was N30,000 which accounted for about 78.53% of the total cost. The competition in cassava root uses among humans and agroindustry could be attributed to high cost of the resource (Nweke, *et al*; 2001). The cost of labour was N4,200, constituted about 11% of total cost of production. The high cost of labour in the study area according to Ume, *et al*;(2020) could be attributed to economic meltdown in the country, leading labourers charging very high to survive. Net returns for 250kg of tapioca processed from 1000kg of cassava root was N36,800. The return on investment was 0.49, implying that in every N1invested 49 kobo accrued. This finding concurred with Alinnor, (2002), who return on investment of 0.52.

Table 2 Constraints to Tapioca processing in the study area

Variable	Frequency	Percentage
Poor access to credit	100	83.33
Poor pricing of products	80	66.67
Irregular supply of roots	98	81.67
Poor road network	45	37.5
High cost of Labour	94	78.33
Drying problem	68	56.67

*Multiple Responses
Source, Field Survey, 2022

Table 2 shows that most (83.33%) of the respondents complained about poor access to credit. The poor access to credit could be related to processors' inability to produce the required collateral as demanded by lending agencies, high interest rate of the loan and ignorance of loan facility in the banks (Ume, *et al;* 2020). Credit could aid in procurement of apart processing equipment, procurement of raw materials and in payment of labour (Nweke, et al; 2002). The least, problem of poor road network were reported by 37.5% of the respondents. This could be related to recent massive rural roads rehabilitations ongoing by various States government in the zone.

CONCLUSION AND RECOMMENDATION

Based on the study, the following conclusions were derived; Tapioca processing was profitable in the study area. More so, the constraints to tapioca processing were poor access to credit, high cost of labour, poor pricing of products, irregular supply of cassava roots and drying problem. Based, on the conclusions, the following recommendations were proffered;(I) Cassava processors should be exposed to credit facilities by commercial banks and microfinance bank at reduced interest rate.(ii)Labour saving devices should be developed and disseminated to the processors at subsidized price (iii)The need to ensure that processors have access to improved drying technologies such as solar drying system to aid in the adequate drying of their products at subsidized cost

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ASSESSMENT OF INCOME DIVERSIFICATION ACTIVITIES FOR LIVELIHOOD IMPROVEMENT AMONG SMALLHOLDERS MAIZE FARMING HOUSEHOLDS IN BUNKURE LOCAL GOVERNMENT AREA (LGA), KANO STATE, NIGERIA

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ABSTRACT

Diversification is an important platform for risk minimization and income complementation. The study assessed income diversification activities among smallholder maize farming households in Bunkure LGA of Kano State, Nigeria. Multi-stage sampling technique was used to select the 60 farming households used in the study. The first stage involved purposively selection of four (4) communities due to large number of farmers. The second stage involved a random selection of fifteen (15) farming household from each community given a total of sixty (60). Primary data was collected from smallholder farming households with structured questionnaire. The data collected was analyzed using descriptive and inferential statistics. The result indicated that about 35.5% of the respondents were between the ages of 35 and 44years; about 59.4% had household size of between 6 and 10 persons. The result of the regression analysis reveals the relationships between most of the variables are significant. There is a significant relationship existing between socio-economic characteristics and income generating activities of the rural respondent in the study area at 1%, 5% and 0%. The result of the research reveals that Access to credit was found to be negatively related to performance of income generating activities. It is therefore recommended that micro-credit should be made accessible for the farmers too should form a body (association, group, cooperative) and farmers so that the credit facility can be easily accessible.

Key words: *Income diversification, livelihood, smallholder, farming household*

INTRODUCTION

Income generation simply means gaining or increasing income or money that an individual or business receives in exchange for providing good or service after investing capital for improvement of livelihood and diversification in other business activities. To achieve this, the sources of income must be diversified. Therefore, income diversification if often referred to as a risk management and coping strategies meant to cushion the effect of economic hardships especially in rural area. It can also be seen as an increase in the number of income or the balance among the different sources of income. When linked to farm and off-farm activities in the rural areas, income diversification is often used to describe expansion in the importance of non-crop and non-farm income. Nonfarm income includes both off-farm wage labor and non-farm employment (Adelekan and Omotayo, 2017). Adekunle and Shittu (2014) states that most rural households adopt multiple income generating activities in order to manage risk in terms of weather change or other factors, to meet household consumption needs in the face of high transaction costs, to take advantage of positive externalities among activities, and to respond to diseconomy of scale.

Statement of the Problem

Multiple motives prompt households and individuals in the area to diversify incomes generating activities. The first set of motives comprises of what are traditionally termed push factors, risk reduction, response to diminishing factor returns in any given use such as family labor supply in the presence of land constraints driven by population pressure and fragmented landholdings, reaction to crisis or liquidity constraints, high transactions costs that induce households to self-provision in several goods and services. Similarly, the current challenges affecting farming household dependent on wet season agricultural production which has been insufficient to cover the food and non- food expenditure of the households despite various income generating alternatives in rural communities in addition to increasing male migration to cities which force women to become sole producers of food for the maintenance of the family. To address these issues, the following objectives were achieved. The broad objective assessed income diversification activities among small holder maize farming households while the specific objectives are to;

i. describe the socio-economic characteristics of the small holder maize farming households,

ii. describe the level of access to productive resources,
iii. describe the type of income diversification activities engaged by the farming households; and
iv. determine the factors influencing their income generating activities in the study area.

Justification of the Study

Diversification of Income generating activities is an essential livelihood component that can help in improving the living standard of smallholder farming households. The study investigates various income generating activities and factors influencing income diversification by realizing the potential and opportunities associated with that for better economic engagement among farming households in the study area. The findings can equally be use by policy makers and development partners for intervention toward improvement of living standard, poverty reduction and reduce the migration of youth to cities for employment which exposes them to danger. In addition, researchers can equally use the findings to fill the gap and make contributions to the existing knowledge.

METHODOLOGY

Study Area

The study area has it coordinates as $11^0$42'N and $8^0$33'E with land area of 9911.22 Km^2. It comprises of (15) fifteen wards with an estimated population of 170,891 in 2006 census. The weather and climate of the area play a great role on the agricultural practices and are favorable to large scale cultivation of cereals, groundnuts, beans and vegetables. The people of the area engaged in crop production and off farm activities during wet season and irrigation activities during dry season as their primary occupation while the secondary occupational include civil service, animal husbandry and marketing of agricultural products (Maryam, *et al.*, 2014)

Sampling Techniques

Multi-stage sampling technique was used in selecting the households. The first stage involves purposive selection of four (4) communities due to large number of farmers. The second stage involved random selection of fifteen (15) farming households from each community and lastly a total of one hundred and fifty-six respondents were interviewed from sixty farming households as presented in table1 bellow

Table 1sampling techniques

S/N	Communities	Households Size	Sample Size
1	Bunkure	15	58
2	Shiyye	15	40
3	Kumurya	15	30
4	Gurjiya	15	28
	Total	60	156

Data Collection and Analytical Techniques

Primary data was collected from smallholder farming households with the use of structured questionnaire. Both descriptive and inferential statistics was used in analyzing the data. Objective1, 2 and 3, were analyzed using descriptive statistics while objective 4 was analyzed using and multiple regression. The explicit form was stated below.

$Y = f(x_1, x_2, x_3, x_4, x_5, x_6, x_7 + e)$

Were,

Y = Dependent variable (number of incomes generating activities engaged in)

$X_1 – X_7$ (independent variables)

Were,

X_1 = Age (Years)

X_2 = Marital status (Dummy variable, married 1; otherwise, 0)

X_3 = Household size (Number)

X_4 = Education (Number of years)

X_5 = Access to credit (access 1; no access 0)

X_6 = Years of experience (Number of years)

X_7= Access to productive resources (effective 1; otherwise, 0)

X_8= Farm management practices (effective 1, otherwise 0)

e = Error term

RESULTS AND DISCUSSION

Socio-Economic Characteristics of Maize Farming Households

Age

The results in table 2 shows minimum age of the people engage in other income generating activities was 24 years and the maximum was 65years. The findings also indicated the sustainability of engagement in income generating activities among the farming household with the engagement of people that are in economic productive age as stated by Onu and Edon (2009) younger farmers have the tendency to operate more efficiently than the older ones because they are more agile and energetic to work.

Marital Status

The findings also revealed that majority (81.1%) of the members within the farming household were married. This implies that there were more married individuals involved in income generating activities than those that are single. This could be associated with the need to support and sustain their families.

Household Size

It was found from the results that the minimum household member found in the households that engaged in income generating activities was 1 with maximum of 15 members. The size of the household may contribute positively to their involvement in the various income generating activities. Ibrahim (2002) reported that family size is relevant to any activities engaged by that household in term of production and other income generating activities.

Educational Level

The findings from the study shows that majority (56%) of the people found within the maize farming household can be able to read and write in western language while (44%) can do that in Arabic language. This implies that the entire respondents had different education background and may be the basis for their engagement in various income generating activities. Muhammed *et al*. (2009) in their studies asserted that level of education is expected to influence farmers' adoption of agricultural innovations, involvement in other income generating activities and decisions on various aspects of farming for sustainable agricultural growth.

Level of Access to Productive Resources

The findings from Table 3 reveals that majority (65.4%) of people found within the maize farming household that engaged in other income generating activities beside production of maize had full access to land as one of the resources used in production. Having access to farmland in rural areas may be associated with the fact that the primary activities of the people in rural areas is farming and they can obtain the lands through inheritance. Similarly, 60.9% of them had full access to labor for production of maize. This is attributed to the fact that, farmers within the communities used family labor in their production activities. The findings further revealed that majority of the farmers within the farming households had no access to capital that aid in production activities in which all other activities rely on. This may necessitate the people to engage in to other income generating activities to be able to compliment in their primary production.

Table 2: Socio-Economic Characteristics of Members of Maize Farming Households

Age of maize farming households	Frequency	Percentage
24-30	15	9.40
31-37	50	32.4
38-44	45	28.8
45-51	31	20.0
52-58	10	6.10
59-65	5	3.05
Total	156	100
Marital Status		
Single	29	18.6
Married	127	81.4
Total	156	100
Household Size		
1 – 5	47	30.1
6 – 10	93	59.6
11-15	16	10.3
Total	156	100
Educational Status		
Primary education	51	32.7
Secondary education	36	23.1
Quranic education	69	44.2
Total	**156**	**100**

Source: Field survey, 2021

Table 3: Level of Access to Productive Resources

Variables	Full Access	Limited Access	No access	Total
	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)
Land	102(65.4)	47(30.1)	7(4.5)	156 (100)
Labor	95(60.9)	48(30.7)	13(8.3)	156(100)
Capital	37(23.7)	35(22.4)	84(53.8)	156(100)
Skill	45(28.8)	71(45.5)	40(25.6)	156(100)
Information	36(23.1)	63(40.4)	57(36.5)	156(100)

Source: Field survey, 2021

Income Generating Activities Engaged by Members of Maize Farming Households

Result in table 4 shows various income-generating activities engaged by people within the maize-farming households in the areas. It can be seen clearly that most (33.5%) of the members engaged in livestock rearing. The livestock were fed with the left over from farming activities. Others (30.7%) engaged in trading of different commodities. Processing of agricultural product more especially among the women was found to be among the activities engaged by the people. The entire activities engaged by the people have in one way or the other relation with their primary activities (farming).

Table 4: Income Generating Activities Engaged by Maize Farming Households (N= 156)

Income generating activities	Frequency	Percentage
Processing of Agro Products	67	26.1
Trucks Driving	25	9.7
Trading	79	30.7
Livestock Rearing	86	33.5
Total	257	100

Source: Field survey, 2021

Factors Influenced Maize Farming Households to engaged in other Income Generating Activities

Table 5: Factors influenced maize farming household to engaged in other income generating activities

Variables	Coefficient	Standard error	T-value	Sig.
Constant	52.702	3.126	15.58***	0.000
Age	4.221	1.352	3.12**	0.034
Access to Credit	-0.173	0.066	-2.25^{NS}	0.291
Access to Productive Resources	0.105	0.934	0.82^{NS}	0.382
Marital Status	0.091	1.262	0.94^{NS}	0.218
Years of Experience	0.132	0.070	1.77*	0.078
Household Size	0.070	0.151	0.46^{NS}	0.898
Education Status	0.873	0.250	0.34^{NS}	0.695
Farm Management Practices	0.366	0.138	2.67*	0.095
R^2	0.72			
R-Adjusted	0.82			
F-ratio	3.38			

Source: Field survey , 2021 *** = Significant at 1% ** = Significant at 5% * = Significant at 10% NS =Not significant

The result of the regression analysis on factors that influenced maize farming household engagement in other income generating activities reveals that the coefficient of age (4.221) was positive and significant at 5% probability level. This implies that the older the person, the more he/she engaged in other income generating activities. Similarly, the coefficient of years of experience (0.132) was found to be positive at 10% probability level implying that more years of farming experience led to engagement in other income generating activities. In addition, the coefficient (0.366) of good farm management practices was also found to be significant at 10% level of probability. This indicates that good farm management practices enhance better productivity and attracting more income from the harvest resulting to saving and use for engagement in to other business for income generation. The coefficient of multiple determination (R^2) value of 0.72 indicates that about 72% of variations in factors was explained by the explanatory variables while the remaining 28% was due to other factors not specified in the model.

CONCLUSION

Based on the findings of the study, it was concluded that maize-farming households engaged in other income generating activities, which were influence by their age, farming experience and good farm management practices for improvement of their livelihood. It was recommended that government and development partners should improve and support access to credit through the establishment of micro-credit scheme and co-operative banks, which will encourage savings and lend loans at low interest rates and establish skills acquisition and entrepreneurial centers where young adults could be trained on the skills and operations of different non-farm activities.

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EFFECT OF MICRO-CREDIT ON VEGETABLE PRODUCTION IN IDO LOCAL GOVERNMENT AREA (LGA) OF OYO STATE, NIGERIA

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ABSTRACT

Finance in terms of credit plays central role in any given investment especially in agriculture and a catalyst for improving the entire agricultural value chain. The purpose of this study was to investigate the effects of micro-credit on vegetable production in Ido Local Government Area of Oyo State. Specifically, the study described the socio-economic characteristics of the respondents, identified the sources of micro-credit that were available to vegetable farmers and examined the effect of micro-credit finance on vegetable farmers' in the study area. A multi stage sampling technique was used in selecting 110 respondents for the study. The data-collecting instrument used for the study was interview schedule. The data were analyzed using frequency and percentages, Mean and linear regression. The study revealed that majority of the vegetable farmers were between the ages of 41and 50 years. They realised annual income ranging from ₦101,000 to ₦200,000. It was also established in the study that there were various sources of fund available to vegetable farmers such as micro finance banks, cooperative societies, and bank of agriculture amongst others. Financing of vegetable production maximally (WMS= 5.0) was one of positive effects of micro finance while loss of valuable properties due to bankruptcy (WMS= 5.0) was one of negative effects of micro finance. The study concluded that vegetable farmers do enjoy this micro finance but effect on farming operations is not encouraging as expected. The study therefore recommended amongst others that programmes that will lead to increase in productivity and considerable policies that will enhance accessibility of loans should be in place by the government.

Keywords: *Micro-credit, vegetable production, effects and farmers.*

INTRODUCTION

Micro-credit is a common form of microfinance that involves an extremely small loan given to an individual to help them become self-employed or grow a small business (Olajide *et al.,* 2012). Micro-credit is also known as "micro lending" or "microloan." The importance of agricultural credit to the overall welfare of farmers is that credit is required to purchase improved technologies like seeds, fertilizers, herbicides, pesticides, agricultural machinery, equipment etc needed for increased productivity and the overall expansion of the farm. Credit is needed to pay salaries of regular staff and wages of farm labour hired for major seasonal tasks. The role of agricultural credit is not restricted to production alone (Boateng and Oduro, 2013). Adegeye and Dittoh (2015) observed that consumption credit, especially to small farmers is a necessity as it provides the necessary impetus to increase labour productivity on farms as well as feeding money before the outright harvesting of crops. Agriculture's contribution to the development process of providing food, capital and labour to the industrial sector and increasing the size of products at the international market is hinged on the availability of credit to farmers (Ikpi and Olayemi, 1994). However, In Nigeria, the government has been a major player in micro-finance services. Government intervention has been due to a lack of modern technology in agriculture, limited savings capacity and the predominance of informal service providers as the sole source of capital. The Nigerian Agricultural and Cooperative Bank (NACB) and other credit enhancing schemes such as the Nigerian Agricultural Credit Guarantee Scheme (NACGS), Nigerian Agricultural Insurance Scheme (NAIS) and the Family Economic Advancement Program (FEAP) are important instruments designed to provide rural and poor economic agents with access to credit (Olawuyi *et al.,* 2010). Poor population possess the capacity to implement income-generating activities but that the main limitation to their initiative is the lack of access to capital. It is based on this background that the study examined the effect of micro credit finance on vegetable production in Ido Local Government Area of Oyo State while specific objectives were to: describe the socio-economic characteristics of the vegetable farmers, identify the sources of micro-credit that were available to vegetable farmers and examine the effect of micro-credit finance on vegetable production in the study area.

METHODOLOGY

Ido is a Local Government Area in Oyo State, Nigeria. Its headquarters is in the town of Ido. It has an area of 986 km²; with and an estimated population for year 2022 to be 148,800 (CityPopulation, 2023). The targeted population of study were the entire vegetable farmers in Ido Local Government. A multi stage sampling technique was used in selecting respondents from the study area. According to Independent National Electoral Commission (INEC), Ido Local Government has Ten (10) wards. Hence, at stage 1, all the ten wards were identified and selected for the study. At stage 2, the number of polling units were collated and identified in each of the wards as follows; Ward 1: Six (6) polling units, Ward 2: Twelve (12) polling units**,** Ward 3; Eight (8) polling units**,** Ward 4: Forty Eight (48) polling units**,** Ward 5: Eight (8) polling units**,** Ward 6: Ten (10) polling units**,** Ward 7: Twenty two (22) polling units**,** Ward 8: Eleven (11) polling units**,** Ward 9: Thirty Nine (39) polling units and **w**ard 10: Thirty One (31) polling units**.** Hence, total number of one hundred and ninety five (195) polling units were identified. At stage 3, based on major crop cultivated, vegetable farmers were purposively selected in each of the 195 polling units. At stage 4, simple random sampling technique was used to select 10% of vegetable farmers selected in each of the 195 polling units to arrive at 110 respondents used for the study. Data collected were analysed using both descriptive and inferential statistics such as frequency and percentages and hypothesis was analyzed using linear regression.

RESULTS AND DISCUSSION

Table 1 revealed that the mean age of the respondents was 45years. This result is similar to a study conducted by Adeyemi and Ogazi (2013) where the mean age was 45.4 years and respondents were said to be in their active age. The Table further revealed that 60.9% were female. This implies that vegetable production was female dominated occupation in the area. Majority (72.7%) of the respondents were married, 11.8% were widow, 8.2% were single and 2.7% were separated. This implies that there is likelihood of family labour availability. About 73.2% of the respondents had secondary school education while 23.6% had no formal education and 3.6% had tertiary education. This implies that majority of vegetable farmers in the study area had one form of education or the other which could assist them to understand what innovation to adopt and practice. Table 1 also revealed that 54.6% were realizing ₦101,000 - ₦200,000. However, 19.6% of the respondents were making ₦51,000 – ₦100,000, while 8.2% were earning ₦301,000 – ₦400,000 and 7.3% made less than ₦50,000 but only 4.5% realized over ₦400,000 as their annual income from vegetable production. This implies that vegetable farmers were realizing various degrees of money from sales of vegetables.

Table 1: Distribution of respondents according to Socio-economic characteristics

Socioeconomic characteristics	Frequency	Percentage	Mean
Age (Years)			
20 -30	11	10.0	
31 -40	32	29.1	
41 – 50	57	51.8	45 years
51 – 60	8	7.3	
> 60	2	1.8	
Sex:			
Male	43	39.1	
Female	67	60.9	
Marital status			
Single	9	8.2	
Married	80	72.7	
Divorced	5	4.5	
Widowed	13	11.8	
Separated	3	2.7	
Educational level			
No formal education	26	23.6	
Primary school	31	28.6	
Secondary school	49	44.6	
Tertiary education	4	3.6	
Years of farming experience(Years)			
≤ 2	8	7.3	
3 – 5	29	26.4	
6 – 8	59	53.6	7 years
> 9	14	12.7	
Annual income (₦)			
≤ 50,000	8	7.3	
51,000 – 100,000	21	19.6	
101,000 – 200,000	60	54.6	₦116,200
301,000 – 400,000	9	8.2	
> 400,000	5	4.5	

Source: Field survey, 2023

Sources of micro-credit available

Data in Table 2 showed the sources of micro-credit available to the vegetable farmers in the study area. The results revealed that all (100%) the respondents claimed that microfinance banks and cooperative societies were readily available sources of micro-credit for their vegetable production. However, 96.4%, 81.8%, and 54.6% asserted that thrifts/contributions, family and friends and informal financial institutions, respectively were the readily available sources of fund. This implies that there were various sources of fund available for them for their farming enterprise. This corroborate Olaitan's (2011) position that universal/development banks, specialized institutions and micro finance banks were the major sources of micro credit.

Table 2: Distribution of Respondents according to sources of micro-credits available

Sources of microcredit *	Yes	No
Bank of agriculture	31(28.2)	79 (71.8)
Commercial banks	10 (9.1)	100 (90.9)
Microfinance banks	110 (100)	0 (0.0)
Cooperative societies	110 (100)	0 (0.0)
Non-governmental organizations	24 (21.8)	86 (78.9)
Informal financial institutions	60 (54.6)	50 (45.5)
Individual money lenders	21 (19.8)	89 (80.9)
Family and friends	90 (81.8)	20 (18.2)
Thrifts/contributions	106 (96.4)	4 (3.6)

Source: Field survey, 2023 * Multiple responses *Figures in parenthesis are percentages

Effects of microcredit finance on vegetable production

Data in Table 3 revealed positive or negative outcome on vegetable production in one way or the other. It was observed that microcredit financed vegetable production maximally as it was ranked 1st. This is in consonant with Shepher (2013) that credit has been recognized as an essential tool for promoting small and medium scale enterprises as well as agricultural production. Loss of valuable properties was ranked 2nd. High interest rate and access to better farming facilities were ranked 3rd and 4th respectively while procurement and sufficient use of inputs was ranked 5th amongst others.

Table 3: Distribution of respondents according to effects of microcredit finance on vegetable production

Effects of microcredit *	**SA**	**A**	**U**	**D**	**SD**	**Wms**	**Ranks**
Helps to finance vegetable production maximally	110	0	0	0	0	5.0	1st
Loss of valuable properties due to bankruptcy	108	1	1	0	0	4.97	2nd
Attracts high interest rates	106	2	1	1	0	4.94	3rd
Helps in procuring and sufficient use of inputs	102	0	6	0	2	4.82	5th
Access to better farming facilities/equipment	100	5	1	2	2	4.81	4th
Assists vegetable farmers to finance farming operations	99	2	6	1	2	4.77	6th
Increased vegetable production	94	10	2	3	1	4.76	7th
Ensures all year round vegetable production	96	4	3	5	2	4.74	8th
Increase in monthly/annual income	82	8	11	3	6	4.43	9th
Better access to education	23	61	16	9	1	3.87	10th
Makes farmers to become perpetual debtors	0	90	12	6	2	3.73	12th
Improved standard of living	20	50	25	5	10	3.59	11th
Provides opportunity for adoption and expansion of modern technologies	60	6	18	10	16	2.96	13th
Better healthcare accessibility	30	16	4	2	58	2.62	14th
Enhances households' varietal consumption	10	9	41	10	40	2.45	15th

Source: Field survey, 2023 * Multiple responses; WMS = Weighted Mean Score

Data in Table 4 established a significant relationship between farming experience (0.00218 **), income (0.01566*) and effect of micro-credit on vegetable production. Farming experience was significant at 0.01 level and income (0.01566*) was significant at 0.05 level. This implies that farming experience and income contributed to micro-credit financing of vegetable production.

Table 4. Results of linear regression analysis establishing relationship between socio-economic characteristics and effects of micro-credit on vegetable production

Socioeconomic characteristics	**Coefficient**	**Standard error**	**t-value**	**p-value**
Constant	65.76905	2.40406	27.357	< 2e-16 ***
Age	0.01466	0.03389	0.433	0.66620
Sex	-0.37614	0.70369	-0.535	0.59413
Farming experience	-0.67607	0.21506	-3.144	0.00218 **
Level of education	0.38039	0.39078	0.973	0.33262

Annual income	0.72348	0.29440	2.457	0.01566 *

Source: Field survey, 2023

Significant codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 3.593 on 103 degrees of freedom

Multiple R-squared: 0.1522, Adjusted R-squared: 0.1028

F-statistic: 3.082 on 6 and 103 DF, p-value: 0.00814

CONCLUSION

Based on the findings of the study, it was concluded that Micro-credit is a life wire for vegetable farmers but farmers' accessibility to other micro credit finance institutions other than cooperative societies needs to be worked on. It was recommended that provision of educational programmes and accessible credit schemes that can facilitate vegetable production should be encouraged. Programmes that will lead to increase in productivity and considerable policies that will enhance accessibility of loans should be put in place. Having realized the effect of micro-credit finance on vegetable farmers, it is highly necessary for all extension agent to encourage the vegetables farmers to join cooperative societies in order to get credit facilities to finance their farming operation. Government should interfere on high interest rate being charged by Micro Credit Institutions.

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ANALYSIS OF THE SOCIO-ECONOMIC CHARACTERISTICS OF THE BENEFICIARIES OF BANK OF AGRICULTURE'S CREDIT IN BENUE STATE, NIGERIA.

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ABSTRACT
The study was on the socio-economic characters of the beneficiaries of BOA agricultural loan and the challenges facing them in Benue state, Nigeria. The study used multistage sampling technique to select 100 respondents and data gotten was analysed with the use of descriptive statistics. Results indicate that the respondents were of active age, male dominated, married, educated with vast experience in farming, large household size, and small scale. Socio-economic characteristics of beneficiaries have great influence on their quest for loan and beneficiaries are faced with myriad of problems. The study recommends the reduction of interest rate to single digit, effective supervision of the credit beneficiaries, and timely disbursement of funds among other things.
Keywords: *BOA, agricultural credit, beneficiaries and loan*

INTRODUCTION
Agriculture in developing countries is characterized by low farm incomes, low level of capacity to satisfy the food and fibre needs of the country and primitive techniques of production. Against the background of the current global food crisis resulting from escalating oil prices and increasing use of food crops as bio-fuels by the industrialized countries, there is need for sustainable agricultural practice and policies that would elevate the nation to the status of self -reliance in food production (Ogah, 2011). Agriculture in the country is under threat due to neglect of the farmers, lack of adequate information and inadequate infrastructure for farming activities and lack of credit facilities which have retarded farmer's effort. (Ogah, 2011). Dwindling budgetary allocation from both federal and state government which is less than 3% of the national budget and the lack of support by the government is part of what is making farming unattractive to vast majority of farmers.

In most developing countries and Nigeria in particular where majority of the farmers are small-holders, the task of agricultural development demands the adoption of new technologies such as the use of improved seeds, fertilizers, herbicides and tractors. To actualise this requires a significant degree of financial commitment. However, because the average Nigerian farmer is poor, they do not have enough capital to adopt these new technologies, the only alternative left for them therefore is credit (Yakubu, 2002). Access to credit will alleviate the capital constraints on agricultural households as expenditures on agricultural inputs must be incurred during the planting and growth periods of crops, while returns are received only after the harvest several months later, therefore to finance the purchase of inputs, the farm household must either dip into their savings or obtain credit (Ogah, 2011).

Realizing the critical nature of agriculture and credit, the Federal Government of Nigeria came up with the strategy of transforming the economy on improving the rural agriculture. One of the measures is the establishment of the Nigerian Agricultural Cooperative and Rural Development Bank (NACRDB) now bank of agriculture (BOA), the single largest agricultural development financial institution in Nigeria which is one of the efforts of the federal government of Nigeria aimed at boosting the delivery of agriculture macro and micro credit to improve agricultural development thereby alleviating poverty among the rural and urban poor Nigerians.

Small scale farmers involved in processing, storage and marketing are faced with enormous difficulties in acquiring credit facilities such as late disbursement of agricultural loans, non-fulfilment of security collateral requirement, diversion of funds by banks management for non-agricultural purposes and inability of the banks to reach small scale farmers at the grass root. Lack of savings and capital make it difficult for many poor farmers to become self-reliant and to undertake productive employment generating activities to increase their income and productivity. Providing credit seems to be a way to generate self- employment opportunities for the poor farmers. Ahmad (2007) had stressed the need for the provision and proper use of credit for small holder to alleviate poverty in in their midst and prevent social unrest. The situation is quite apt for Nigeria where past government policies were highly skewed in favour of investment in construction, transport and commercialization sectors with higher returns to the detriment of the primary sectors with slow or low returns. The result is huge accumulated deficit in funding/ investment needs for agriculture in order to stimulate growth.

This action is also compounded by liberal import tariff policies, weakened manpower status of the rural agriculture sector which encourage rural urban migration, expansion of monetary supply with its attendant inflationary pressure on the economy all of which combine with above to retard progress in the agricultural sector, perpetuate poverty, ill health, poorly educated populace of Nigeria leaving credit as the only option available. Researchers like Awotodunbo, (2008), Olagunju, (2007) and Sisay, (2008) focused on financial constraints to small scale farming, impact of credit use on resource productivity and determinants of small holder farmer's access to formal credit thereby creating a vacuum on the socio-economic characteristics of the beneficiaries of bank of agriculture agricultural credit in Benue state, Nigeria, which is the gap to be filled. The study has the following objectives: to describe the socio-economic characteristics of the beneficiaries of BOA credit and the constraints they faced.

METHODOLOGY

The study was conducted in Makurdi Local Government Area of Benue State, Nigeria. The area was chosen because of the location of BOA in the area. It lies between latitude $7^0 38'$ N and $7^0 50'$N and between longitude $8^0 54'$ E and $8^0 38'$E with usual temperature of 32.5 degree cencius. It has an estimated population of 300,377 (NPC, 2006) and covers a land mark of 835,624km sq. It experiences a typical climate with two distinct seasons, rainy season, which lasts between April and October and the dry season which is characterized by harmattan dry wind from November to March. The area is inhabited by the Tivs, Idomas, Igedes, Jukuns, and other ethnic groups like Hausas, Yorubas, Ibos, Anglo, Akwenyas, Etulos among others. The people are predominantly farmers who engage in agriculture and grow wide range of crops like yam, maize, sorghum, cassava, sweet potatoes, rice soybeans etc. The area was chosen because of the activities of the cooperatives.

A multi-stage sampling technique was used in the selection of the small scale farmers that formed the sample. In the first place, five council wards were selected by means of simple random sampling, in the second stage, 20 small scale farmers from each of the council ward were selected proportionately by means of random sampling to give the total of 100 respondents for the study. Data were collected from primary source with the use of questionnaire to illicit the needed information for the study. The data collected were analysed with the use of descriptive statistics like frequency distribution, percentages, mean and the use of tables.

RESULTS AND DISCUSSION

Socio-economic Characteristics of the Beneficiaries of BOA Agricultural Credit

The results of the socio-economic variables of the respondents are presented in Table 1. From the results, most of the beneficiaries (43%) were in the age bracket of 41-50 years. This is not unexpected as population within this age limit is an active and productive population that can engage in farming activities. This corroborates the findings of Ogah et al (2021) that this age group is a productive population. The mean age of 43 years is an indication that BOA like other financial institutions will only extend credit to agile and productive population. From the analysis, most of the beneficiaries are males (81%) while females are 19%. As noted by John, (2015), females are under the direct legacy of their husbands and therefore cannot acquire credit from the banks without the approval of their husbands. From the results, 98% of the respondents have one of education or the other. This is in important as the loan terms will have to be read and understood. Specifically, 18% have primary education, 35% have secondary education, 45% have tertiary education while only 2% do not have any formal education. This is in line with the findings of Ogah et al (2018) that most loan beneficiaries in Benue state are educated. Further scrutiny on Table 1 indicates that 9% of the beneficiaries have been farming for less than 5 years, those with 5-10 years of experience are 19% while 33% have been farming for more than 21 years. The mean farming experience of 13 years is an indication that the beneficiaries are not novice in the use of credit. This agrees with the findings of Ogah et al (2017). From Table 1, the mean household size is 7 persons for the beneficiaries this is large and will help in farming business and serves as support to the agricultural credit. Ogah et al (2021) have noted large household size for the farming communities in Nigeria. From Table1, it can be seen that most of the beneficiaries are small holder with 78% cultivating 1-3 hectares. The mean farm size of 1.5 hectares is a testament on why agricultural credit is needed to support their production. Collaborating this, Ogah et al (2018) asserted that majority of Nigeria farmers are small holders. Analysis from Table 1 revealed that most of the beneficiaries are married and this constitutes 75%. In other categories, the singles are 11%, divorced 8% and widowed 6%. The high proportion of the married is an indication that they are responsible and will make use of the credit judiciously. Under African culture as noted by Ogah et al (2017), marriage is a sign of responsible individual and maturity and therefore people that are married command more respect and can access credit easily.

Table 1. Distribution of Beneficiaries according to their Socio-Economic Variables in the Study Area n=100

Variables	Frequency	Percentage (%)	Mean
Age(years)			43
21-30	5	5	
31-40	20	20	
41-50	53	53	
51-60	17	17	
>60	5	5	
Sex			

Male	81	81	
Female	19	19	
Educational level			
No education	2	2	
Primary	18	18	
Secondary	35	35	
Tertiary	45	45	
Marital status			
Single	11	11	
Married	75	75	
Divorced	8	8	
Widow	6	6	
Farming exp(years)			
<5	9	9	
5-10	19	19	
11-15	20	20	
16-20	19	19	
>21	33	33	
Farm size(ha)			1.5
<1	9	9	
1-3	78	78	
>3	13	13	

Source: Field survey, 2022

Constraints faced by Beneficiaries in Obtaining Agricultural Credit from BOA

Table 2 provides detail analysis of constraints faced by the respondents in their quest for agricultural credit. From Table 2, the high-ranking problem is the interest rate which is 90%. Most of the respondents complained of high interest rate as the rate is double digit instead of single digit. The matter is made worse with the increasing inflationary rate which washed off the value of the naira. Most of them advocate for single digit rate for them to break even This collaborates the findings of Thirumalaisany *et al* (2016) who reported high interest rate as problem facing farmers. Another serious constraint faced by the beneficiaries in the study area was delay in approval of loan as the loan is not given in time to meet up with the farming activities. The study revealed that 80% of the respondents complained of this problem.

The issue here is that sometimes the farming season might have gone before the loan is disbursed and therefore farmers could not invest the loan on agricultural activities and will have to wait till another farming season. This issue often leads to diversion of loan for other use. This agrees with the findings of Ogah, (2011) who noted that agricultural credit farmers in Katsina and Kaduna states, Nigeria have problem of delay disbursement of loan. Another issue of concern to the beneficiaries is the problem of having to meet the minimum saving amount before the credit is disbursed. As most of the farmers are small scale there is barely enough to eat not to talk of saving to meet the minimum saving required by the bank. From the analysis, 65% of the respondents had this problem. Other problem is lack of supervision by the bank staff which constitutes 52%. According to the beneficiaries, they are often left unattended to and no supervision by the bank staff to ascertain whether the credit has been utilised or not. This could actually lead to diversion of the loan funds. This is in agreement with the findings of Ogah, (2011). Other concerns are insufficient amount which is 48%, short repayment period 42%, administrative bottleneck 37% and too many trips to the bank which constitutes 28% responses.

Table 2 Distribution of Respondents Based on Constraints Faced in the Study Area

Problem	Frequency	Percentage
High rate of interest	90	90
Delay in loan approval	80	80
Minimum saving requirement	65	65
Lack of supervision	52	52
Insufficient amount	48	48
Short repayment period	42	42
Administrative bottle neck	37	37
Too many trips to bank	28	28

Multiple responses, Source: Field survey, 2022

CONCLUSION AND RECOMMENDATIONS

Socio-economic characteristics of BOA agricultural credit beneficiaries have great influence in loan disbursement as BOA tends to skewed funds disbursement towards active and productive population. The beneficiaries of the agricultural credit are faced with myriad of problems which could militate against effective use of the agricultural credit. The study recommends the reduction of interest rate to single digit, effective supervision of the credit beneficiaries, timely disbursement of funds to meet up with farming season and smoothening of administrative procedures for the beneficiaries. Having these in place, BOA will rightly be placed to live up to the expectations of Nigeria farmers.

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ASSESSING THE DEGREE OF COMMERCIALIZATION OF SELECTED STAPLE CROPS PRODUCTION AMONG FARMING HOUSEHOLDS IN SOUTHERN AGRICULTURAL ZONE OF BORNO STATE, NIGERIA

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ABSTRACT
This study assessed the degree of commercialization of selected staple crops among farming households in Southern Agricultural Zone of Borno State, Nigeria. A simple random sampling technique was used to select 180 respondents for the study. Data collected were analyzed using descriptive and Double-Hurdle Model. Results revealed that majority (78.9%) of the respondents were male while only 21.1% were female. A large proportion (64.4%) of the respondents were within the age bracket of 31-50 years. most (51.1%) of them had between 6-10 persons per household. Many of the respondents (36.7%) had between 21-30 years of farming experience; majority (60.0%) of them were educated and most (85.6%) of the farmers did not belong to any cooperative association while More than half of the farmers (52.8%) hard between1-2 hectares of farm land. The most commercialized crop was cowpea with a commercialization index of 0.84. This was followed by groundnut (0.74) and maize (0.73). The least commercialized crop was rice with an index of 0.65. The variables that affected commercialization of smallholder staple crop were marital status, household size, and membership of farmers association and were significant at 1%, 5%, and 1% respectively. Constraints to staple crop commercialization among farmers were poor market information, low output prices, inadequate transportation facilities, unfavourable contract farming agreements, and high post-harvest losses. Conclusively, cowpea enterprise has the highest commercialization index (0.85), while rice has the least (0.65). It was recommended that more extension agents be trained so that more farmers could be reached, and good storage facility should be made available to reduce post-harvest losses.
Keywords: *Commercialization, Staple crops, Smallholders*

INTRODUCTION
According to conventional wisdom, the transition from subsistence (or semi-subsistence) to commercial agriculture represents a key ingredient for the economic development of low-income countries. By exploiting comparative advantages, food crop commercialization enhances trade and efficiency, leading to economic growth and welfare improvement at the national level. This is further expected to initiate a virtuous cycle which raises household income, thus improving consumption, food security and nutritional outcomes inside rural households (Carletto, 2017). The Agricultural sector grew by 4.88% in third quarter of 2016, and recorded 26.06% in 2020, suggesting immense unrealized potentials (Adepoju, 2018). Participation in commercialized agriculture holds considerable potential for unlocking suitable opportunity necessary for providing better income and sustainable livelihood for small scale farmers (Adenegan, 2011). Commercialization among smallholder farmer in developing countries has often been signalled as being a vital tool for the upliftment of countries economic condition and food security of the farmer's household (Dioula, 2013).
Agriculture continues to be a strategic sector in the development of Nigeria where smallholder farming is the dominant livelihood activity for the rural areas (FAO, 2018). Moreover, the rate of agricultural growth depends on the speed with which subsistence oriented production system is transformed into a market orientated production system (Diro, 2016). Consequently, agricultural commercialization remains a widely pursued approach in development projects to improve food security in low-income countries (Linderhof, 2019).). By so doing, it does not only bring the welfare benefits of market-based exchange economies to this group, but is central to an inclusive development process (World Development Report, 2016; Arias, 2013; Gezachew, 2018). Despite the importance of smallholders and commercialization in inconomic and income generation, the traditional system of agriculture stii prevails with it's characteristics of low technological base, high reliance on manual labor hence low resource productivity. Bridging the gap of paucity of information about the degree of commercialization among smallholder crop farmers necessitated this study. The objective was to assess the degree of

commercialization of selected staple crops production among farming household in southern agricultural Zone of Borno state, Nigeria.

METHODOLOGY

The study was conducted in selected local Government areas of southern Agricultural Zone of Borno State, Nigeria. The selected local government areas were Askira/Uba, Biu and Hawul because most farmers in the selected areas grow and market the selected crops. Borno State is lying within latitude 11. 8846^{0}N, 11.4959.99^{0}N and longitudes 13.1520^0'E and 13.900^{0}E, of the Greenwich Meridian, which has an area of 61,435sqkm. The rainfall is highly seasonal with marked wet and dry seasons.. Normally the rainy season begins in June and terminates in September or early October (between 4 - 5 months) while the dry season begins in October and terminates in May (between 7-8 months).

A simple technique was used for the study. Purposive selection of three (3) LGA Areas from the nine LGA in the study area. Three districts each LGAs and two villages from each districts were purposively selected. Ten (10) registered farmers were randomly selected from each villages making a total number of One hundred and eighty (180) respondents.

Data Analysis

Descriptive statistics such as frequency distribution tables, means, percentages and standard deviations, Household crop output commercialization index (HCOCI) and Craig's double hurdle model were used.

The Craig's double hurdle regression models were specified as follows:

$$P(y=0|x)=1-\mu(x\alpha)$$

$$\log(y|x,0)=1(y=0)\ln\left[\mu,\left(\frac{x\beta}{\delta}\right)\right]+1(y>0)\ln\left|\frac{\mu(x\beta)}{\mu\left(\frac{x\beta}{\delta}\right)}\right|+\ln\left[\frac{1}{\delta\sqrt{2\pi}}\exp(-\frac{1}{2\delta^2}(y-x\delta^2))\right]$$

HCOCI = Household crop output (production) commercialization index

a = gross value of crop sale

b = gross crop production value Y =Participation for the crops production commercialization (maize, rice, cowpea and groundnuts) (=1 if participated in the production, 0 otherwise)

RESULTS AND DISCUSSION

Socio-economic Characteristics of Respondents

Socioeconomic Characteristics of the Respondents are Presented and Discussed as Follows:

Age: The information from table1 revealed that larger proportion (32.2%) of the respondents were within the age bracket of 31-40 years. The mean age was approximately 42 years implying that the respondents were active individuals of economic phase.

Gender: Majority (78.9%) of the respondents were male while only 21.1% were female. This implies that the proportion of male-headed households is higher than that of female-headed households...

Marital Status

The marital status result revealed that majority (75.0%) of the respondents were married, while 20.6% were single. Similarly, 3.3%, and 1.1% were widowed and divorced respectively.

Farming Experience

Shows that larger proportion of the respondents (36.7%) had between 21-30 years farming experience, while 28.9% had between 11-20 years of farming experience.

Years of Formal Education

Information on the respondents' years of formal education shows that majority (60.0%) had spent between 13-18 years in formal education. This implies that the respondents were literate and hence, can read and write

Table 1 Socio-Economic Characteristics of Small Holder Staple Crop Farmers

Socioeconomic characteristics	Frequency	Percentage	Mean
Gender			
Male	142	78.9	
Female	38	21.1	
Total	180	100.0	
Age			
20-30	26	14.4	
31-40	58	32.2	
41-50	58	32.2	41.5
51-60	32	17.8	

Above 60	6	3.3	
Total	180	100.0	
Marital status			
Married	135	75.0	
Single	37	20.6	
Divorced	2	1.1	
Widow	6	3.3	
Total	180	100.0	
Household size			
1-5	60	33.3	
6-10	92	51.1	7.2
11-15	27	15.0	
16-20	1	0.6	
Total	180	100.0	
Farming experience			
1-10	12	6.7	
11-20	52	28.9	
21-30	66	36.7	25
31-40	36	20.0	
41-50	10	5.6	
Above 50	4	2.2	
Total	180	100.0	
Years of formal education			
0 years	8	4.4	
1-6	29	16.1	
7-12	32	17.8	12
13-18	108	60.0	
19-24	3	1.7	
Total	180	100.0	
Membership of farming association			
No	154	85.6	
Yes	26	14.4	
Total	180	100.0	
Extension contact			
No	152	84.4	
Yes	28	15.6	
Total	180	100.0	
Farm size			
Less than 1	3	1.7	
1-2	95	52.8	
3-4	57	31.7	
5-6	23	12.8	2.6
7-8	2	1.1	
Total	180	100.0	

Source: Field survey, 2021

Level of Commercialization of Selected Crops

The level of commercialization of selected crop is shown in Table 2 showed that the most commercialized crop was cowpea with a commercialization index of 0.84. This may be due to the high price and income generated in the sale of this crop compared to other crops produced in the study area. This was followed by groundnut (0.74) and maize (0.73). The least commercialized crop was rice with an index of 0.65.

Table 2: Level of Commercialization of Selected Crops

Gross Values	**Maize (₦)**	**Groundnut (₦)**	**Cowpea (₦)**	**Rice (₦)**
Gross value of Crops sold (a)	735,742.62	175,417.78	198,822.69	106,700.13
Gross value of crop produced (b)	1,011,353.11	237,801.39	237,406.26	164,747.42
Output Commercialization index	0.73	0.74	0.84	0.65

Source: Field survey, 2021

Determinants of Staple Crop Commercialization Decision of Farmers

The variables that affect commercialization of staple crop were determined using the Double-Hurdle Regression Analysis. Table 3 shows a log likelihood of 73.994626 and a chi-square of 47.54 both at 1 percent level of significance.. From the results, marital status (-0.0589738), household size (-0.0100916), and membership of farmers association (-0.1436261) were the only significant variables influencing household commercialization decision at 1%, 5%and 1% level of significant respectively.

Table 3 Determinants of Factors that Influence Commercialization Decision of Farmers

Variable	Coefficient	Std. Err.	z- Statistic	Prob.
Gender	0.0313094	0.0446741	0.70	0.483 NS
Age	-0.0002342	0.0029544	-0.08	0.937 NS
Marital status	-0.0589738	0.0209702	-2.81	0.005***
Household size	-0.0100916	0.0048334	-2.09	0.037**
Farming experience	0.0007654	0.0025724	0.30	0.766 NS
Years of schooling	-0.0011012	0.0029446	-0.37	0.708 NS
Farmers association	-0.1436261	0.0487907	-2.94	0.003***
Number of extension contact	0.0049028	0.0132157	0.37	0.711 NS
Farm size	0.0145798	0.0108984	1.34	0.181NS
Constant	0.7245658	0.0886982	8.17	0.000

*** 1% significance level
**5% significance level
Log Likelihood = 73.994626
chi^2 (14) 47.54 Prob>chi^2 = 0.000
Pseudo R^2 = 0.7683.

CONCLUSION AND RECOMMENDATIONS

Based on the findings of this study, it can be concluded that the level of commercialization of selected crops was high with cowpea having the highest commercialization index. Socioeconomic characteristics of the farmers such as their marital status, household size, and farmers association strongly influenced commercialization decision of the respondents in the study area. Based on the findings, the following recommendations were made; To mitigate post-harvest losses, farmers need to be provided with enough and good storage facilities to ensure that food crops produced in excess are stored in order to make it available throughout the year at an affordable prices.Supports in forms of credit facilities and input subsidy be provided to the farmers so that they can produce large quantities for commercialization. Various governments and NGOs concerned should assist in providing an accessible road network that can help farmers move their produce easily.

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BENEFIT-COST ANALYSIS AND RICE PRODUCTIVITY AMONG SMALLHOLDER FARMERS IN RIYOM LOCAL GOVERNMENT AREA OF PLATEAU STATE, NIGERIA

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ABSTRACT
Rice is an important staple food crop and Nigeria has the capacity to be self-sufficient in rice production. However, production capacity is far below national requirements; domestic production and enterprise profitability are critically constrained. Therefore, this study analyzed profitability and rice productivity among smallholder farmers in Riyom, Plateau State, Nigeria. For this study, 108 respondents were selected using a multistage sampling method. Collected data were analyzed using farm budgeting and total factor productivity techniques. The estimated total and net returns were respectively ₦243,200 and ₦103,700 per hectare; indicating a profitable enterprise, with potentials for improved economic prospects. Additionally, the benefit-cost ratio was estimated to be 0.74. Further, the majority of rice farmers (53.7%), whose TFP indices were below the optimal scale, were producing sub-optimally; due to an inefficient mix of inputs and the high cost of factors of production. Therefore, this study recommends improved access to agricultural credit and farm capital; improved cooperative activities, input supply and subsidies, policy modifications, development and adoption of agricultural production technology, improved extension service delivery and farmer sensitization.
Keywords: *Benefit-cost, productivity index, small holder farmers, rice production*

INTRODUCTION
Rice belongs to the genus *Oryza* and the family *Gramineae*. Rice is the world's important staple food crop. Rice is mainly produced and consumed by small-scale farmers in low income and developing countries such as Nigeria (NBS, 2012). Rice (*Oryza spp*.) is the fourth major cereal in Nigeria after sorghum, millet, and maize in terms of farm output and cultivated land area (RIMIDAN, 2012; Shehu *et al*., 2007). Rice is a basic food for most households in sub-Saharan Africa and Nigeria in particular. A shift in the demand for rice has changed the perception of it being a luxury food to a major source of calories for most households in Nigeria (Osawe *et al.*, 2017). The leading world producers of rice are Japan, Indonesia, Taiwan and Brazil (FAO, 2016; FAOSTAT, 2013). In Africa and particularly sub-Saharan Africa, Nigeria is the largest producer of rice, producing an average of 3.2million tonnes of rice (Obianefo *et al.*, 2019). Rice cultivation is wide spread within the country extending from the northern to southern zones with most rice grown in the eastern and middle belt of the country. Nigeria has the capacity to be self-sufficient in rice production. Virtually all ecologies in the country are suitable for rice cultivation. Rice in Nigeria is typically grown all year round in Nigeria, either as rainfed or by irrigation. In Nigeria rain fed lowland system account for approximately 25% of the harvested area: rain fed upland system account for 50%; irrigated system account for 16%; and deep water or mangrove swamp account for less than 10% of the total rice production area (Obianefo *et al.,* 2019). Moreover, there are over 20 species of rice, however, only two are cultivated types, the rest are wild species. The cultivated species are *oryza sativa* and *oryza glaberrima* (FAO, 2016; FAOSTAT, 2013). The two species are believed to have originated separately: *Oryza sativa* from Asia (India and China), while *oryza glaberrima* from Africa (West Africa) (FAOSTAT, 2013; RIMIDAN, 2012; Shehu *et al*., 2007).

Although rice contributes a significant proportion of the food requirements of most households, the production capacity is far below national requirements; and despite the rise in cultivated area, demand for rice relative to other major staple food continuous to rise above the level of domestic production; with consumption broadening across all socio-economic classes (Osawe *et al.*, 2017). In Nigeria, rice output is low and declining; the decline is traceable to inefficient use of farm resources, labour shortages and scarcity and high cost of farm inputs, poor management practices and inadequate farm capital. Domestic production is also constrained by low input and poor crop management techniques by small-scale farmers as well as inadequate water control techniques. To meet the increasing demand, the importation of milled rice was used to bridge the gap between domestic demands and supply (CBN, 2012). A major reason for this trend was adduced to a sizable rice yield gap between attainable and actual farm yield. Nigeria has depended heavily on imported rice to meet her consumption needs and has become the world's largest importers of rice, with well over ₦150.15billion expended annually on rice importation; indicative of the declining self-sufficiency in rice production (CBN, 2012). Small-scale farmers have attempted in achieving efficient rice production but lack modern inputs and capital to exploit the economic potentials of their farmlands. Additionally, most farmers do not keep farm records, which affects research aimed at assessing the profitability of agricultural production by comparing the cost of input and output level (Onuwa *et al*., 2022). Thus, it becomes imperative to analyze the profitability and index of rice productivity in Riyom, Plateau State, Nigeria. This study will provide useful recommendations, which will go a long way to facilitate improved yield in rice production. Based on the foregoing, this study aims to provide answers to the following research questions: (a) Is rice production profitable? (b) What is the index of rice productivity?

METHODOLOGY

The Study Area

The study was conducted in Ganawuri district, Riyom Local Government Area (LGA) of Plateau State. The LGA has a total land area of about 807km^2 (NBS, 2012). Riyom LGA consists of three (3) districts namely Riyom, Bachit and Ganawuri, with two major ethnic groups (Berom and Aten). The LGA is located at Northern Guinea savannah, with coordinates at longitude 9^{o}38'N and latitude 8^{o}46'E (NBS, 2012). Annual rainfall varies between 1000mm and 2000mm, with a mean temperature of 25^{o}C. Most of its population are farmers, cultivating food crops such as rice, maize, fonio, Irish potatoes, cabbage, etc.

Sampling Procedure

Multistage sampling procedure was used to draw sample for the study area. In the first stage, Riyom LGA was purposively selected, based on the intensity of rice production in the area. The selection was done to reflect the most typical situation for rice based farming systems. In the second stage, Ganawuri district was purposively selected. This is the major rice producing district in the study area. The third stage involved random selection of respondents from a list of rice farmers complied by trained enumerators from the selected district. In all, 108 respondents were selected for the purpose of this study and validated using the raosoft sample size calculator with a confidence level of 95% and a margin of error of 10% adapted from Onuwa *et al*. (2022).

Method of Data Collection

Structured questionnaires designed in line with the objectives of the study were used for data collection.

Analytical Techniques

Primary data collected were evaluated using farm budgeting model and Total Factor Productivity (TFP) technique. The farm budget technique (costs and returns analysis) was used to determine the costs, returns and profitability of rice production in the area. The Total Factor Productivity (TFP) technique was used to estimate agricultural productivity by comparing an index of agricultural inputs to an index of outputs. Therefore, a combination of statistical and budgetary techniques was used in the analysis of the collected data as adapted from (Onuwa and Wuyep, 2023; Onuwa, 2022).

Farm Budget (Profitability) Analysis

The farm budgeting models used are presented in Equations (1), (2), (3) and (4), respectively as adapted from Onuwa and Wuyep (2023):

NR=TR-TC …….. (1)

Where: NFI= net return; TR=Total return (₦); and TC=Total cost (₦)

$TR = P_Y.Y_I$ …….. (2)

Where: P_Y = output unit price (₦); and Y_I = output quantity (kg)

Total Cost (TC) =TVC+TFC …….. (3)

Where: TC = Total cost (₦); TVC=total variable cost (₦); and TFC=total fixed cost (₦)

$TVC = P_X. X_I$ …….. (4)

Where: P_X = variable input unit price (kg or liter) [Seed (₦), fertilizer (₦), labour cost (₦), and agrochemicals (₦)]; and X_I = Input quantity (kg or liter); and TFC = Total fixed cost (₦) (farm tools and equipment's). To further substantiate the profitability of this enterprise, the benefit-cost ratio (BCR) was also estimated and specified in Equations (5), as adapted from (Onuwa *et al*., 2022; Onuwa, 2022):

Benefit-cost ratio (BCR) = Net return /Total cost …….. (5)

Total Factor Productivity

By comparing an index of agricultural outputs to an index of agricultural inputs, total factor productivity (TFP) can be used to calculate agricultural productivity. This can be computed following Onuwa and Wuyep (2023) in equation (6):

$$\frac{TFP}{TVC}=\frac{Y}{TVC}=\frac{Y}{\sum PiXi} \text{ ……… (6)}$$

Where: Y = quantity of output; TFP = Total Factor Productivity; TVC = total variable cost; Pi = unit price of the ith variable input; and Xi = quantity of ith variable input. This method does not take into account the role of total fixed cost (TFC) because it does not affect the conditions for resource-use efficiency or profit maximization. The TFP index can be interpreted as follows:

(< 0.1) = Sub-optimal; (1.0 – 1.09) = Optimal; and (≥ 1.10) Super-optimal.

RESULTS AND DISCUSSION

Costs and Return of Rice Production

The cost and returns analysis in Table 1 shows that the total cost of producing rice per hectare in the study area was ₦ 139,500,while the average total and net return were ₦243,200/ha and ₦103,700/ha, respectively. The components of variable costs comprised 85.7% of the total production cost, while total fixed cost components comprised 14.3%. Also, the estimated benefit cost ratio was 0.74 (BCR<1), which indicates that rice production is a relatively profitable enterprise in the study area. Thus, the farmer earned ₦0.74 on every naira spent on rice production. Hence, rice production in the study area is a very viable farm enterprise with prospects of improved economic potentials. This conforms to Onuwa and Wuyep (2023); Onuwa (2022); Obianefo *et al.* (2019) who, in their respective studies on agricultural profitability, reported outcomes that were comparable.

Table 1: Cost and returns analysis for rice production (₦/ha)

Variables	Amount (₦/ha)	%
A. Returns		
(i)Total output (tonnes/ha): 1.9		
(ii)Price (₦/ton):128,000		
(iii) Total return = ₦243,200		
B. Variable cost:		
(i) Fertilizer	55,000	39.4
(ii) Agrochemicals	32,000	23
(iii) Seed	14,500	10.4
(iv) labour	18,000	12.9
Total Variable cost	119,500	85.7
C. Fixed cost		
(i) Farm tools & equipment	20,000	
Total fixed cost	20,000	14.3
D. Total cost	139,500	100
E. Net return	103,700	
F. Benefit-cost ratio:	0.74	

Source: Field survey, 2016

Total Factor Productivity Analysis

According to the summary statistics of the total factor productivity result in Table 2, the majority of rice farmers (53.7%) were producing less than optimally because their TFP indices were below the optimal scale. This indicates that the production process did not allocate the right mix of inputs. According to their TFP indices, 31.5% were optimally productive, while 14.8% were found to be super-optimally productive because their TFP indices were higher than the optimal scale. The low output in the various cucumber farms in the study area could be attributed to a sub-optimal input mix and high production input costs. This corroborates with Onuwa *et al.* (2022); Cechura *et al.* (2014) whose studies on agricultural productivity profiles yielded comparable findings.

Table 2: Distribution based on total factor productivity of rice farmers

Productivity index	Frequency	Percentage
Sub-optima (<1.00)	58	53.7
Optima(1.00-1.09)	34	31.5
Super-optima (>1.10)	16	14.8

Source: Field survey, 2016

CONCLUSION

The findings showed that rice farming was moderately profitable, with possibilities for improved economic prospects. Additionally, the majority of cucumber farmers' TFP indices were below the optimal range, indicating sub-optimal productivity owing to sub-proficient information, poor innovation reception and significant expense on production inputs. The study recommended: (a) Strengthens policies to improve access to agricultural credit for smallholders; (b) Public-Private sector partnerships that ensures adequate provision and distribution of production inputs/technologies at subsidized rates; and (c) Improved farm cooperative activities that facilitate access to inputs such as fertilizers, herbicides, seeds, etc., as well as efficient produce marketing. Inaddition, adoption of modern practices and technology that automates production; minimizes labour costs and optimizes productivity, agricultural extension activities in the study area need to be strengthened to provide improved agricultural techniques to farmers, and modifications to tenure policies to reduce farmland fragmentation; and increased sensitization on modern management practices that mitigates farm risks (pest/disease outbreaks) and improves productivity.

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ANALYSIS OF ECONOMIC SUPERIORITY OF FARO 68 TO OTHER RICE VARIETIES IN NIGERIA

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ABSTRACT
The work was carried out to examine the economic superiority of FARO 68 to other rice varieties and checks in Nigeria. The results of the On-station trials in 2019 and 2020 shows that genotype ARS161-3-5-3-B-BD was late (82 days) to reach 50% flowering, had the highest number of tillers per square meters and was late (109 days) to maturity. It also recorded the highest grain yield of 6974.50kg/ha. The mean performance of yield and some traits of lowland genotypes and checks during multi-locational trials at 9 locations for 2 years were observed. The genotype ARS161-3-5-3-B-BD recorded clear lead in the grain yield value (7165.95kg/ha). The highest single year grain yield recorded by ARS161-3-5-3-B-BD was 11556.22kg/ha at Edozhigi, Niger State in the 2021 cropping season. However, the combined means of yield performance showed that ARS161-3-5-3-B-BD recorded the highest yield of 10194.78kg/ha at Edozhigi according to Table 3. The On-farm Trials were conducted by14 farmers (14 sites) across 11 States in 2021; the result is presented in Table 4. The monetary value and economic gain of ARS161-3-5-3-B-BD is also presented in Table 5 below and proof to be superior over others.
Keywords: *Checks, economics, faro 68, genotype, superiority*

INTRODUCTION
The present rice cultivated may hardly be enough for the country to be self-sufficient in food consumption for population growth now and in future to come. If the growth in demand and consumption is more than production, there will be shortage, which endangers the security of food in the nation (Familusi and Oranu, 2020). The rice demand projection for 2030 is 19,796,832,353 kg equivalent to 67.35% growth in 2030 (Familusi and Oranu, 2020). The total supply projection of rice in Nigeria is at 8,773,617,507 kg equivalent to 56.92% in rice production coming 2030, while estimated population size stand at 26.60% by 2030. The expected estimated for demand and consumption for rice is higher by 2.26% than the nation production of rice, therefore there is need to increase the rice production. The area expansion of rice production is no longer solution to increase rice availability, but through frontier technologies. The potential yield of the commercial variety in lowland ecology is about 10 tons per hectare in the country. However, National Cereals Research Institute (NCRI) with national mandate on genetic improvement and development on rice, in collaboration with African Rice Centre in Cotonou and the Rice - maize Centre, Ibadan have developed some lowland rice genotypes that have agronomical superiority and better grain quality to the varieties in farmers' fields. In addition, the new genotypes could outperform the available national checks in yield and resistance to prevailing biotic and a biotic stresses in the country. The developed genotype ARS161-3-5-3-B-BD is having superior agronomic traits, comparative nutritional attributes to the checks and average grain yield advantage of 32.92% and 58.09% over and above the FARO44 and FARO 67 respectively as national checks. The objective is to quantify the economic value in monetary term the superiority of FARO 68 (Plate 1) over other varieties.

Plate 1. FARO 68 plant and Grains are shown above

METHODOLOGY

On-station trials On-station evaluations were carried out at the Fadama Rice Research fields of National Cereals Research Institute Headquarters, Badeggi, Niger State, Nigeria in the 2018 and 2019 growing seasons. The selected genotypes and two (2) popular national checks (FARO 44- high yielding, FARO 67- recently released) were evaluated for yield and yield-related agronomic traits. The experiments were in Randomized Complete Block design, replicated three (3) times.

Multi-location trials were conducted by NCRI in 2020 and 2021. The experiments were carried out in nine sites namely; Wushishi (Niger), Badeggi (Niger), Kebbi (Kebbi), OLAM (Nassarawa), Warri (Delta), Akure (Ondo), Numan (Adamawa), Edozhigi (Niger) and Abakaliki (Ebonyi) state respectively,

Seven (7) selected genotypes (ARS 161-3-5-3-B-BD, ARS 563-14-B-ED, ARS 150-TGR-10-NCRIB-12, ART 64-26-1-1-B-B-ED, D 56-NCRIJ-1-1, ART 90-46-1-1-B-B-ED, ART 739-2-6-B-BD) and two (2) national checks (FARO 44, and FARO 67) were evaluated for their yield performance. The trials were laid out in a randomized Complete Block Design. Each entry was planted in a 4 x 3m^2 plot size in three replications, the nursery was raised and three weeks old seedlings were transplanted in single seedling per stand. Fertilizer application was at 80, 40 40 kg per ha of N, P_2O_5 and K_2O, with N applied at two splits at 21 and 42 days after transplanting (DAT). Weed was controlled by Propanil and 2-4-D formulation at 4 liters per hectare of Orizo Plus, with supplementary hand weeding through GGE Biplot to identify ideal and stability of the genotypes across environments was also carried out. Reactions to biotic and abiotic stresses were scored.

On-farm trials were conducted by National Rice and Maize Centre (NRMC) in collaboration with National Cereals Research Institute, (NCRI) Badeggi at the respective State Agricultural Development Projects (State ADPs). Fourteen farmers in eleven States of the Federation were randomly selected. Three best genotypes (ARS 161-3-5-3-B-BD, ART 739-2-6-B-BD, and ARS 563-14-B-ED) selected from the multi-location trials were composed for the On-farm trials alongside farmers' variety (FARO 44) as check. This was conducted using farmers' fields and planting methods. In conjunction with Extension Agents of respective States ADPs, field days and Participatory Varietal Selection (PVS) to assess the Farmers' Preference and Ranking of criteria for the genotypes and check were conducted in Niger, Ebonyi, Oyo and Kebbi States.

RESULTS AND DISCUSSION

The results of the On-station trials in 2019 and 2020 are presented and the combine means are in Table 1.The genotype ARS161-3-5-3-B-BD was late (82 days) to reach 50% flowering, had the highest number of tillers per square meters and was late (109 days) to maturity. ARS161-3-5-3-B-BD also recorded the highest grain yield of 6974.50kg/ha followed by ARS563-14-B-BD (5917.50kg/ha) and D56-NCRIJ-1-1 (5429.5) and FARO 67 (5415.00).

Table 1: Combined Mean Performance of agronomic traits for Lowland Rice Genotypes during On-Station trial at Badeggi in 2018 and 2019

S/No.	Genotypes	DFF	PH (cm)	PL (cm)	NTPMS	NPPMS	DM	GY (kg/ha)
1	ARS161-3-5-3-B-BD	82.0	112.5	21.35	821.5	488.5	109.60	6974.5
2	ARS563-14-B-BD	66.5	110.0	23.8	659.5	328.0	99.515	5917.5
3	ARC150-TGR10-NCRIB-1-2	75.0	115.0	23.7	654.0	450.5	101.94	5377.0
4	ART71-96-1-1-B-B-ED	77.0	130.0	24.7	582.5	294.0	99.26	4430.0
5	ART64-26-1-1-B-B-ED	77.5	128.5	24.3	608.5	339.5	110.28	4574.5
6	D56-NCRIJ-1-1	80.5	98.5	23.95	650.0	393.0	104.67	5429.5
7	ART93-112-1-1-B-B-ED	76.5	147.0	26.9	609.0	331.0	100.21	3706.0
8	ART90-46-1-1-B-B-ED	72.5	125.0	24.75	642.5	517.0	106.81	4714.0
9	ART61-52-1-1-B-B-ED	77.5	146.0	25.25	634.5	429.5	98.285	3753.5
10	ARS739-2-6-B-BD	68.0	117.0	25.0	722.5	535.5	100.74	4672.0

11	IR77429-50-B-5-3-B-TGR1	74.5	123.5	25.95	633.5	423.5	102.36	3945.0
12	FARO 44	77.0	113.5	24.35	565.5	447.5	102.43	4508.5
13	FARO 67	95.0	127.5	29.02	455	313.0	114.08	5415.0
	Mean	76.9	122.62	24.85	633.73	407.0	103.86	4878.2
	CV%	2.5	2.65	3.71	8.76	11.9	3.64	15.5
	SE	1.9	3.26	0.9224	55.51	48.5	3.78	758.2
	LSD	7.8	13.1427	3.7242	224.11	195.7	15.26	3061.0

DFF= Days to 50% flowering, NTPSM = Number of tillers per square meter, NPPSM = Number of panicles per square meter, PH = Plant height (cm), PL = Panicle Length (cm), DM = Days to maturity, GY = Grain yield (kg/ha). FARO 44 and Faro 57 = Checks.

Table 2 indicates the mean performance of yield and some traits of lowland genotypes and checks during multi-locational trials at 9 locations for 2 years. Significant differences were observed for all the traits studied. Means were separated using Llkeast significant difference at 5% probability and the values are indicated. The genotype ARS161-3-5-3-B-BD also recorded clear lead in the grain yield value (7165.95kg/ha) followed by ART 739-2-6-B-BD(5765.97kg/ha).

Table 2.Mean Performance of yield and some traits of Lowland Rice Genotypes during Multi-locational Trial at 9 locations in 2020 and 2021

Genotypes	DFF	PH (cm)	PL (cm)	NTPMS	NPPMS	DM	GY (kg/ha)	YAOC1	YAOC2
ARS 161-3-5-5-3-B-BD	85.04	113.09	23.49	657.44	513.55	110.64	7165.95	32.92	58.09
ARS 563-14-B-ED	78.75	116.18	26.06	431.44	396.5	112.34	5666.8	5.11	25.01
ARS 150-TGR-10-NCRIB-12	78.38	114.45	27.27	404.76	399.00	103.34	5424.31		
ART 64-26-1-1-B-B-ED	75.94	106.02	26.11	436.28	397.22	98.54	5419.8		
D 56-NCRI J-1-1	76.79	116.26	24.94	404.11	404.11	108.54	4771.47		
ART 90--46-1-1-B-B-ED	75.51	115.15	26.07	352.58	391.78	110.43	5059.84		
ART 739-2-6-B-BD	79.58	119.64	25.53	403.39	398.22	104.67	5765.97	6.95	27.20
FARO 44 (check 1)	76.88	114.27	28.17	434.49	405.13	102.46	5391.3		
FARO67 (check 2)	79.78	125.26	29.54	373.28	383.82	109.45	4532.98		
Mean	78.52	115.59	26.35	433.09	409.93	106.71	5466.49		
CV%	4.80	2.54	2.70	2.54	6.94	2.87	14.07		
SE	1.77	2.39	0.58	8.98	13.41	2.50	362.45		
LSD	5.698	8.52	2.07	31.94	43.0481	8.89	1163.558		

DFF= Days to 50% flowering, NTPSM = Number of tillers per square meter, NPPSM = Number of panicles per square meter, PH = Plant height (cm), PL = Panicle Length (cm), DM = Days to maturity, GY = Grain yield (kg/ha). FARO 44 = check 1 and Faro 57 = Check 2, YAOC1 = Yield Advantage over Check 1, YAOC2 = Yield Advantage over Check 2

In Table 3 the highest single year grain yield recorded by ARS161-3-5-3-B-BD was 11556.22kg/ha at Edozhigi, Niger State in the 2021 cropping season. However, the combined means of yield performance showed that ARS161-3-5-3-B-BD recorded the highest yield of 10194.78kg/ha at Edozhigi according to Table 3, while FARO 67 recorded the least value (3253.46kg/ha) at Badeggi also in Niger State.

Table 3. Yield performance during Multi-Locational Trial of Lowland Rice Genotypes at 9 locations in 2020 and 2021

GENOTYPES	Wushishi		Rukubi		Akure		Badeggi		Kebbi	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
ARS 161-3-5-5-3-B-BD	5307.88	5837.76	9510.03	8468.22	6751.36	6459.84	7461.65	5591.44	5558.86	5937.87
ARS 563-14-B-ED	5612.26	6987.35	7940.16	2559.86	6853.9	4457.85	5503.3	4424.54	5529.45	5783.37
ARS 150-TGR-10-NCRIB-12	4713.08	6840.65	5550.06	5637.76	4898.44	6330.26	2856.92	6050.88	5327.45	4511.08
ART 64-26-1-1-B-B-ED	5501.34	6714.23	5663.27	5681.84	5659.85	4132.34	2222.54	6600.42	4742.88	4557.26
D 56-NCRI J-1-1	4157.83	5934.34	4097.88	5098.34	4627.34	7236.46	4062.85	3224.95	5127.32	4371.88
ART 90--46-1-1-B-B-ED	5331.02	4987.34	5857.43	4863.42	4857.28	5874.1	3923.35	6744.37	4001.65	4521.47

ART 739-2-6-B-BD	5618.28	5493.23	6620.93	8393.43	6329.98	7390.44	5246.88	6298.45	4942.84	5630.85
FARO 44 (checkl)	5341.21	5008.46	5457.24	8345.33	6077.23	4876.34	3518.23	4548.87	4243.35	4509.38
FARO67(check2)	5801.98	3153.52	6737.09	3169.24	4730.22	3219.65	3476.06	3030.86	4907.33	4659.42
Mean	5264.99	5661.88	6381.57	5801.94	5642.85	5553.03	4252.42	5168.31	4931.24	4942.51
CV%	2.13	2.31	2.65	3.03	2.80	2.58	3.01	1.87	1.88	2.57
SE	91.59	106.70	138.31	143.57	129.22	117.12	104.35	78.78	75.62	103.73
LSD	325.839	379.59	492.02	510.74	459.70	416.65	371.21	280.26	269.027	369.01

Table 3 Contd.

GENOTYPES	Numan		Abakaliki		Warri		Edozhigi	
	2020	2021	2020	2021	2020	2021	2020	2021
ARS 161-3-5-5-3-B-BD	5578.88	6043.76	6391.76	7864.86	8146.56	7686.89	8833.34	11556.22
ARS 563-14-B-ED	5283.06	6008.25	3761.32	6398.56	6848.33	4987.87	5600.25	7462.76
ARS 150-TGR-10-NCRIB-12	5086.83	5497.46	3150.55	6628.78	6477.88	6876.82	4867.96	6334.76
ART 64-26-1-1-B-B-ED	4500.04	5286.66	3612.54	5298.45	7870.23	7534.83	4433.84	7543.76
D 56-NCRI J-1-1	4427.37	3098.65	4097.27	3863.87	7172.06	5343.54	4567.81	5376.72
ART 90--46-1-1-B-B-ED	4901.85	4287.43	2774.44	4265.87	6516.32	6554.87	4267.43	6547.45
ART 739-2-6-B-BD	5339.32	5980.45	4916.82	4863.78	4725.84	6218.87	4300.82	5476.22
FARO 44 (checkl)	3729.56	4876.23	4199.48	4972.56	5372.35	6321.45	7300.48	8345.67
FARO67(check2)	3830.43	4126.88	3133.32	5438.76	6798.95	5624.88	4533.16	5221.86
Mean	4741.93	5022.86	4004.17	5510.61	6658.72	6350.00	5411.68	7096.16
CV%	3.52	3.01	2.53	3.33	2.99	2.22	2.03	2.41
SE	136.29	123.35	82.69	149.62	162.32	115.02	89.67	139.84
LSD	484.861	438.82	294.17	532.26	577.44	409.17	319.00	497.4825

The On-farm Trials involved 14 farmers (14 sites) across 11 States in 2021, the result is presented in Table 4.ARS161-3-5-5-3-B-BD showed clear yield (6637.82kg/ha) superiority over other selected *lowland rice* genotypes and the national commercial check, followed by ART 739-2-6-B-BD (4875.97kg/ha). The analysis of variance showed significant differences amongst the *lowland* genotypes and the check variety.

Table 4. Mean Performance of Yield during On-farm Trial in 11 Statesin 2021

S/No.	Genotype	Nasarawa	Kebbi	Kwara	Kano	Ondo	Jigawa	Adamawa	Anambra
		Olam	Kebbi	Bacita	Kano	Akure	Kazaure	Yola	Anaku
1	ART 739-2-6-B-BD	4256.0	3382.1	4186.40	4153.3	4177.1	3922.5	5254.2	5288.3
2	ARS 161-3-5-5-3-B-BD	7474.7	7693.5	5285.40	4687.4	5974.5	6297.4	5846.3	6788.5
3	ARS 563-14-B-ED	4358.5	3953.8	4114.00	3342.9	4365.9	5885.0	4533.8	5343.9
4	FARO 44	4556.9	3932.1	3835.82	3254.9	3743.2	4841.3	4508.0	5621.3
	MEAN	5161.53	4740.38	4355.41	3859.63	4565.18	5236.55	5035.58	5760.50
	SE	773.58	993.22	319.07	342.07	487.52	534.54	320.83	350.32
	CV%	29.97	41.90	14.65	17.73	21.36	20.42	12.74	12.16

Table 4 contd.

S/No.	Genotype	Kogi	Oyo			Niger				G. MEAN
		KotonKarfe	Ibadan	Ologun	Mean	Wushishi	Edozghigi	Badeggi	Mean	
1	ART 739-2-6-B-BD	5438.8	5721.10	4934.90	5328.00	6322.90	6837.80	4388.20	5849.63	4875.97
2	ARS 161-3-5-5-3-B-BD	6948.4	6526.10	6398.90	6462.50	7865.10	8357.50	6785.80	7669.47	6637.82
3	ARS 563-14-B-ED	5296.5	3893.70	3920.50	3907.10	4949.00	5187.60	3554.90	4563.83	4478.57
4	FARO 44	4924.7	4254.90	4923.80	4589.35	5654.00	5987.50	4821.10	5487.53	4632.82

MEAN	5652.10	5098.95	5044.53	5071.74	6197.75	6592.60	4887.50	5892.62	5156.30
SE	445.48	618.39	510.26	422.41	622.55	677.94	685.14	243.26	229.92
CV%	15.76	24.26	20.23	8.33	20.09	20.57	28.04	5.06	11.80
LSD				1344.30				595.25	465.06

The current economic situation and price of rice at 350 naira per kg indicate that cultivation of ARS161-3-5-3-B-BD gives more money to the famers and has difference of up to 524,705.5 naira and even more when compare to other rice varieties as indicated in Table 5 below.

Table 5.Economic Superiority of FARO 68 over other rice varieties and checks in yield

Genotypes	Grain yield /ha	Yield different/ha	Economic value/ha (₦)	Economic advantage (₦)
ARS161-3-5-3-B-BD	7165.95		2,508,082.5	2,508,082.5
ARS-563-14-B-ED	5666.8	1499.15	1,983,380.00	-524,705.5
ARS-150-TGC-10-NCRIB-12	5421.31	1744.64	1,897,458.5	-610,597
ART-64-26-1-1-B-B-ED	5419.8	1746.15	1,896,930.00	-611,152.5
D-56-NCRI-J-1-1	4771.47	2394.48	1,670,014.5	-838,062.5
ART90-46-1-1-B-B-ED	5059.84	2106.11	1,770,944.00	-737,138.5
ART739-2-6-B-BD	5765.97	1399.98	2,018,089.5	-489,993
FARO44 (Check1)	5391.3	1774.65	1,886,955.00	-621,127
FARO67(Check2)	4532.95	2633	1,586,532.5	-921,550

On bases the performance of ARS 161-3-5-5-3-B-BD at the on-station, multi-location and on-farm trials, and farmers' preference over checks, including tolerant to stresses, tit is recommended that ARS 161-3-5-5-3-B-BD be adopted and cultivate by farmers in lowland ecologies in Nigeria.

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ASSESSMENT OF THE PRODUCTIVITY AND PROFITABILITY OF IFAD-VCDP BENEFICIARIES UNDER TUNGA-KAWO IRRIGATION SCHEME IN NIGER STATE, NIGERIA

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ABSTRACT
The study examines the productivity and profitability of IFAD beneficiaries under Tunga-kawo irrigation scheme Niger State. Multi-stage sampling techniques were used to select 118 beneficiaries and 119 non-beneficiaries on which primary data were elicited with the aid of a structured questionnaire complemented with interview schedule. Data were analyzed using descriptive statistics (such as frequency, percentage and mean), Farm budget technique and total factor productivity. The study revealed that the average age of rice farmers in the study area was 38 with average farming experiences of 24 years. The beneficiaries had at least secondary education while the non-beneficiaries had at least primary education. The cost and return revealed that rice production in the study area was productive with a net farm income of ₦1,783,543.22 and ₦550,788 for both beneficiaries and non-beneficiaries respectively although the beneficiaries demonstrated higher levels of productivity compared to non-beneficiaries. Also, the mean TFP index for beneficiaries and non-beneficiaries were 8.82 and 3.40 respectively. The study recommended that to further enhance rice productivity in the study area, efforts should be made to expand access to improved seeds, irrigation facilities, and extension services not only for beneficiaries but also for non-beneficiaries. This can be achieved through government programs and partnerships with agricultural organizations.
Keywords: *IFAD-VCDP, Farm Budget Technique, Total Factor Productivity, rice farmers*

INTRODUCTION
Rice is a critical food crop for millions of people in Nigeria and Africa, providing essential food security, nutrition, and income for many households in the region (FAO, 2018). In Nigeria, rice is a major staple food and is consumed by millions of people, but the country still faces a significant gap between domestic rice production and consumption, leading to a high level of dependence on imported rice (International Rice Research Institute (IRRI), 2017). To address these challenges, the agriculture sectors in Nigeria have placed a high priority on increasing rice production in the region. This is achieved through various initiatives aimed at boosting rice production, such as improving irrigation systems, developing improved rice seed varieties, and providing support for small-scale farmers (Babatunde and Oyebanji, 2017). One of such initiatives is the International Fund for Agricultural Development (IFAD) Value Chain Development Programme (IFAD-VCDP) which aims at improving cassava and rice value chains for smallholder farmers in 9 States. Tungan Kawo Irrigation Scheme is one of the intervention areas under IFAD-VCDP in Niger State. Despite these efforts, Nigeria faces significant challenges in meeting the food demands of its growing population. The population growth rate stands at 3.2% annually, while food production is increasing at a slower rate of 2.5% per year (National Bureau of Statistics (NBS), 2022). It is against this background that this study was carried out to describe the socioeconomic characteristics of rice farmers in study area; determine the net returns from rice production for beneficiaries and non-beneficiaries of IFAD-VCDP intervention in the study area; and determine the productivity level of both the beneficiaries and non-beneficiaries of IFAD-VCDP in Tunga-Kawo Irrigation intervention.

METHOLOGY
The study was carried out in Niger State which is located within 8^0 22'N and $11^0$30'N and Longitudes 3^0 30'E and 7^0 20'E with an average annual rainfall in the State is 1,219 mm. The State covers an estimated total land area of 74.244sq.km, which is about 8% of Nigeria's total land area with a 3,950,249, comprising 2,082,725 males and 1,867,524 females (National Population Commission (NPC), 2006). The projected population of the State as at 2021 was 5,644,139 at 3.2% population growth (NBS, 2022).

Multi-stage sampling procedure was employed in the selection of 118 beneficiaries and 119 non-beneficiaries of IFAD-VCDP farmers under Tungan-Kawo Irrigation Scheme, Niger State. Primary data were elicited from the respondent with the aid of a structured questionnaire complemented with interview schedule. Descriptive statistics (such as mean, frequency distribution count, and percentages) were used to analyze the data collected. Farm budgeting approaches and total factor productivity were utilized to describe the enterprise's profitability and productivity.

RESULTS AND DISCUSSIONS

Socioeconomic and demographic characteristics of respondents

Table 1 revealed that the average age of beneficiaries and non-beneficiaries rice farmers in the study area was 38 years. This implies that the respondents in the study area were in the prime of their productive years with the energy required for labour-intensive agricultural activities. Also, younger farmers may be more flexible in their decisions to adopt new ideas and practices. Result in Table 1 also reveals that majority (93.2%), (91.6%) and (92.4%) of the beneficiaries, non-beneficiaries and the pooled sample respectively were married. This implies that married rice farmers dominate rice production in the study area. Marriage often signifies the establishment of a household, and in many agrarian societies, family members actively participate in farming activities. This finding corroborates with that of Aminou *et al*. (2019) who reported that majority of rice farmers in Niger were married. Results from the study also reveals that the average farming experience of beneficiaries, non-beneficiaries and the pooled sample were 24, 23 and 24 years respectively. This implies that experienced rice farmers dominate rice production in the study area which is expected to enhance the productivity of rice production in the study area. The results also revealed that most (61.0%) of beneficiaries had one forms of formal education or the other with an average of 8 years of formal education. Also, 53.6% of non-beneficiaries had formal education with an average of 5 years of formal education. This implies that rice farmers in the study area had moderate level of education with at least secondary and primary education for beneficiaries and non-beneficiaries respectively. This is expected to enhance the productivity of rice farmers in the study area. The result in Table 1 revealed that all the beneficiaries of IFAD-VCD programme had access to extension while only few (1.7%) had extension in the last farming cycle. This suggests that access to agricultural extension services is significantly higher among beneficiaries of the IFAD-VCD program compared to non-beneficiaries. Table 1 revealed that nearly half (44.9%) of beneficiaries and 25.2% of non-beneficiaries had access to credit. This implies that beneficiaries of the IFAD-VCD program have a higher percentage of access to credit compared to non-beneficiaries although access to credit among the two groups is below average. The higher percentage of beneficiaries with access to credit suggests that the IFAD-VCD.

Table 1: Distribution of respondent according to socio economic and demographic characteristics of rice farmers

	Beneficiaries (N=118)		Non-beneficiaries (N=119)		**Pooled (N=237)**	
Variable	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
Age						
< 21	48	40.68	30	21	56	23.63
21-30	62	52.58	40	33.61	92	38.82
31-40	8	6.78	49	41.18	89	37.55
Mean	**38**		**38**		**38**	
Marital status						
Married	110	93.2	109	91.6	219	92.4
Single	4	3.4	10	8.4	14	5.9
Widowed	4	3.4	0	0	4	1.7
Farming experience						
10-20	48	40.68	54	45.38	102	43.04
21-30	62	52.54	52	43.70	114	48.10
31-40	8	6.78	13	10.92	21	8.86
Mean	**24**		**23**		**24**	
Level of formal education						
Non-formal	46	39.0	64	53.8	110	46.4
Primary	10	8.5	22	18.5	32	13.5
Secondary	30	25.4	24	20.2	54	22.8
Tertiary	32	27.1	9	7.6	41	17.3

Mean	**8**		**5**		**6**	
Extension contacts	118	100.0	2	1.7	120	50.6
Access to credit	53	44.9	30	25.2	83	35.0

Source: Field survey, 2023

Cost and returns from rice production for beneficiaries and non-beneficiaries of IFAD-VCDP intervention

Table 2 present cost and return of rice production for both beneficiaries and non-beneficiaries in the study area. The Table revealed that the average Total Variable Cost (TVC) of beneficiaries and non-beneficiaries were ₦326,688.14 and ₦211,707 respectively, which accounts for 91.76% and 89.14% of the total cost of rice production for both group respectively, while the Total Fixed Cost (TFC) of beneficiaries and non-beneficiaries was ₦29,318.64 and ₦25,799.7 respectively accounting for 8.24% and10.86% of the total cost incurred by both beneficiaries and non-beneficiaries respectively. The calculated gross margin was ₦1,812,861.86 and ₦576,587 for both beneficiaries and non-beneficiaries respectively. It is significantly higher for beneficiaries as compared to the non-beneficiaries. This suggests that the intervention has positively impacted the productivity and profitability of rice farming for the beneficiaries.

Similarly, the net income was ₦ 1,783,543.22 and ₦ 550,788 for both beneficiaries and non-beneficiaries respectively**.** The net farm income was positive for both groups which imply that rice production in the study area is generating profits, although the beneficiaries had higher NFI compared to the non-beneficiaries. The estimated rate of return was 5.01% for beneficiaries and 2.32% for the non-beneficiaries This indicates that for every unit of cost invested in rice production, beneficiaries are generating a return of 5.01% while non-beneficiaries generating 2.32% but to a lesser extent compared to beneficiaries. The benefit cost ratio was 6.01 and 3.32 both beneficiaries and non-beneficiaries respectively. This implies that for every unit of cost invested in rice production, beneficiaries are generating a return of 6.01 units in terms of benefits. Also, non-beneficiaries had positive benefit-to-cost ratio, but to a lesser extent compared to beneficiaries. Gross ratio of 0. 17 indicates that for beneficiaries, the total costs incurred are 83% of their total returns. In other words, beneficiaries can retain 17% of their total returns as gross margin while the gross ratio of 0.30 for non-beneficiaries suggests that their total costs constitute 70% of their total returns, allowing them to retain 30% of their total returns as gross margin.

Table 2: Cost and returns from rice production for beneficiaries and non-beneficiaries of IFAD-VCDP intervention

variable cost	Amount	% of Total Cost	Amount	% of Total Cost
	Beneficiaries		**Non-Beneficiaries**	
Cost of labour	2300	0.65	2360.5	0.99
Seed cost	18667.80	5.24	27043.7	11.39
Fertilizer cost	194559.32	54.65	85596.6	36.04
Herbicide cost	32000	8.99	23395	9.85
Insecticide cost	5084.75	1.43	1361.34	0.57
Cost of processing	34864.41	9.79	34521	14.53
Cost of transportation	14169.49	3.98	11823.5	4.98
Cost of shop rent	5211.86	1.46	5974.79	2.52
Cost of bagging	13957.63	3.92	16907.6	7.12
Cost of storage	5872.88	1.65	2722.69	1.15
Total variable cost (TVC)	326688.14	91.76	211707	89.14
Fixed cost				
Depreciation on cutlass, Sickle, Hoe, Axe, Wheel biro, Knapsack,	29318.64	8.24	25799.7	10.86
Total fixed cost (TFC)	29318.64	8.24	25799.7	10.86
Total Cost (TC)	356006.78	100	237506	100
Total return	2139550		788294	
Gross Margin	**1812861.86**		**576587**	
Net Income (NI)	**1783543.22**		**550788**	
Rate of return	**5.01**		**2.32**	
Benefit Cost Ratio	**6.01**		**3.32**	
Gross Ratio	**0.17**		**0.30**	

Source: Field survey, 2023

Productivity level of both the beneficiaries and non-beneficiaries of IFAD-VCDP in Tunga-Kawo Irrigation intervention

The result in Table 3 presents the productivity level of both the beneficiaries and non-beneficiaries of IFAD-VCDP in the study area. The Table revealed that majority (**96.61%)** of beneficiaries was within the super-optimal level, indicating that most beneficiaries are achieving high productivity levels while above average (**63.87%**) of non-beneficiaries fall in the sub-optimal categories indicating that a significant proportion of them experience moderate levels of productivity. The mean TFP index for beneficiaries and non-beneficiaries were 8.82 and 3.40 respectively. The mean TFP index of 8.82 for beneficiaries signifies that, on average, the group experiences a notably higher level of total factor productivity.

Table 3: Productivity level of both the beneficiaries and non-beneficiaries of IFAD-VCDP in Tunga-Kawo Irrigation intervention

TFP index	Frequency	Percentage	Frequency	Percentage
	Beneficiaries		**Non-beneficiaries**	
Sub-optimal (0.1 – 2.9)	2	1.69	22	18.49
Optimal (3.0 – 4.9)	2	1.69	76	63.87
Super-optimal (5.0 and above)	114	96.61	21	17.65
Total	118		119	
Mean	8.82		3.40	
Minimum	.58		1.99	
Maximum	63.55		6.92	
Standard deviation	8.38		1.08	

Source: Field survey, 2023

CONCLUSION AND RECOMMENDATION

Based on the findings of the study it can be concluded that beneficiaries demonstrated higher levels of productivity compared to non-beneficiaries. They had a higher average level of formal education with access to extension services. The study recommended that to further enhance rice productivity; efforts should be made to expand access to improved seeds, irrigation facilities, and extension services not only for beneficiaries but also for non-beneficiaries. This can be achieved through government programs and partnerships with agricultural organizations.

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ECONOMIC ANALYSIS OF LIVELIHOOD INCOME ACTIVITIES ON FOOD SECURITY STATUS OF RURAL FARMING HOUSEHOLDS IN NIGER STATE, NIGERIA.

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ABSTRACT

This study analyzed the economic effects of livelihood income activities on food security status of rural farming households in Niger state, Nigeria. Undertaking diverse livelihood income generating activities is one of the key strategies often adopted to tackle the challenge of food insecurity in Niger State by rural farmers. Three Local government areas were randomly selected namely: Mokwa, Mashegu and Paikoro from the three Agricultural zones in Niger State. Primary data were used only for the study, The data were obtained with the aid of structured questionnaire. Data collected were analyzed using descriptive statistics such as frequency counts, percentages and mean, and inferential statistics. The specific objectives of the study were to; describe the socio-economic characteristics of respondents, identify their various livelihood activities, determine their food security status, identify the determinants of householdfood security of the respondents and lastly, identify the constraints to diversifying livelihood sources in the study area. A multistage sampling technique was used to collect primary data from 240 rural household heads using structured questionnaire. Data collected were analyzed using descriptive and inferential statistics. The result revealed that 90% of the respondents were male and 88.57% were married. Majority (70%) were educated and are mostly small scale farmers (about 96%). Similarly, they undertake other diverse livelihood income activities whichare mostly unskilled non-farm activities. The mean per capita food expenditure per month was estimated to be ₦12,588.12 and the value was used to establish the food security line which showsthat 68.7% of the households were food secure. The binary logit regression analysis showed thatthe coefficients of education level(X_5), number of income generating activities(X_6), remittance(X_9) and farmsize(X_{10}) were positive and significant at $p<0.1$ and $p<0.05$ respectively, while that of household size (X_4) was significant but negative. The major constraints to diversifying livelihood income activities include; inadequacy of funds, infrastructural problems, and lack of awareness/training. The study recommended that, effort should be made by all development actors to; improve access to credit by farmers, provide basicinfrastructure in the area, and lastly integrate awareness creation on diversifying livelihood income activities into extension massages.

***Keywords**: Livelihood income, households, food security*

INTRODUCTION

In many developing countries, and particularly in Africa, agricultural income represents an essential component of rural households' subsistence. However, this type of income exhibits a high seasonality and leads to uncertain outcomes, mainly due to market prices volatility and environmental hazards. Consequently, household members partly allocate their working time to activities which provide a more stable income so as to cope with adverse shocks (Ellis, 2000). In Nigeria and some other developing countries traditional image of farm households has been that,they focus almost exclusively on farming and undertake little rural off-farm economic activities (Reardon *et al*., 2006). Successive governments in Nigeria have made efforts to achieve food security in the country by trying to boost food production through the setting up of a number of Agricultural Development Institutions, and Special Programmes and Projects. In recent decade, such effort in that regard include: the National Agricultural Development Fund [NADF] in 2002; National Special Programme on Food Security [NSPFS] in 2002; National Food Crisis Response program [NFCRP], Food Security Thematic Group [FSTG] in 2009, and the present administration's Growth Enhancement Support [GES] under the Agricultural Transformation Agenda [ATA] in 2011. Sanchez (2005) defines food security as a situation where people do have physical and economic access to sufficient, safe, nutritious and culturally acceptable food to meet their dietary needs to lead a healthy and active life. Off-farm income activities generally plays a vital role in sustainable development and poverty reduction in rural areas (Shehu and Abubakar, 2015). It reduces the pressure of unemployment and the demand for land by the poor in rural areas; contributes to breaking down the vicious cycle of poverty among the rural populace and the income obtained from off-farm activities can significantly increase total household income and hence enhance the investment capacity in farm activities (Babatunde *et al.*, 2010). Therefore, off-farm income activities is often a source of savings, which plays an important role in food security and livelihood. The households that diversify their income by participating in off-farm income activities are more capable of overcoming negative shocks from poor harvest (Myyra *et al.*, 2011).

However, despite these government efforts, empirical records of many of these initiatives are not impressive enough to have achieved the objectives for which they were initiated, leaving an overwhelmingly large proportion of Nigerians food insecure (Idachaba, 2004; Azubuike, 2012; Jerome, 2012; Adepoju and Adejere, 2013). Agriculture being the traditional livelihood source has failed to guarantee sustainable livelihood opportunities for these farmers in this country and in many other developing nations (Barrett and Reardon, 2000; Kydd, 2002; Davis and Bezemer, 2004; Muyunda, 2009; Dary and Kuunibe, 2012; Babatunde, 2012; Uche, 2012).

Improved food security is important for global reduction of hunger and for economic development. In the year 2000, world leaders committed themselves to the Millennium Development Goals (MDGs) and one of their aims is to eradicate poverty and hunger, and "reduce by half the proportion of people who suffer from hunger" between 1990 and 2015. Currently, 820 million people are affected by hunger in developing countries and the number of hungry people in the world is growing at an alarming rate of four million a year; this trend is not falling quickly enough to achieve the food security goals particularly in Africa and southern Asia.

Despite the growing world abundance of food, food-related crises continue to occur. Differences in food security statuses within countries are common, even if the country has sufficient food in aggregate during normal periods. There have been increased observations of inequalities in the sufficiency of food intake by certain groups despite overall adequacy of supply. However, since the World Food Conference of 1974, the focus on the topic "Food security" has moved from a global and national perspective to that of households and individuals. Food security as a complex and multidimensional phenomenon alongside poverty is nowadays defined as "A situation when all people at all times have physical and economic access to safe, efficient and nutritious food needed to maintain a healthy and active life". Nord and Hopwood also defined it as "An access by all people at all times to enough food for an active life.

Food insecurity is closely linked with poverty. The average income and poverty measures, however, do not provide clear information about food security. It may, therefore, be incorrect to assume that a state, country, region, community or household's poverty prevalence rate is the same as its food insecurity or hunger prevalence rate, since the relationship between poverty and food insecurity is not a consistent one. A wider definition of food security incorporates quality of life indicators. Accordingly, food security implies livelihood security at the level of each household and all members within, and it involves ensuring both physical and economic access to a balanced diet, safe drinking water, environmental sanitation, primary education and basic health care. An important aspect of the wealth of a nation is its ability to make food available and accessible to its populace. The social and economic development of a nation is dependent on the quality of its human and non-human resources. The productivity of a nation's human resources is, however, a function of how well fed the citizens are and how healthy they are at all times.

In Nigeria, the percentage of food insecure households was reported to be 18% in 1986 and over 40% in 2005. Howbeit, figures released by Food and Agricultural Organization in 2005 on the state of food insecurity in the world indicated that about 29% of the Nigerian population was chronically undernourished between 2000 and 2002 . This was less than the regional average of 33% for sub-Saharan Africa. However, the 29% or about 40 million undernourished Nigerians translate to about 5.4% of total number of undernourished people in sub-Saharan Africa as a whole.

The main objective of this study is to analyze the economic effects of livelihood income activities on the food security status of rural farming households in three Local Government Area of Niger state, Nigeria. The specific objectives to be achieved are to :

i. describe the socio-economic characteristics of the respondents;
ii. identify the various livelihood income activities among the respondents;
iii. determine the food security status of the respondents;
iv. identify the determinants of household food security of the respondents; and

MATERIALS AND METHOD

The study area.

The study was conducted in Niger State, it is located between Latitudes $8^0 22^/$N and $11^0 30^/$N and Longitudes $3^0 30^/$E and $7^0 20^/$E, and covers 76,363 square kilometers of land mass which makes it the largest Nigerian State by land mass. However, using the population growth rate of 3.2%, the projected population of the State was 6,764,755 as the end of 2021.

Method of Data Collection

Primary data was used for the study. The data were collected using a well-structured questionnaire administered to the respondents by the researcher through multi stage sampling techniques

Analytical Techniques

Combinations of analytical techniques were used to analysed data collected from the field. It include descriptive statistics and inferential statistics. Multi-stage sampling technique was employed in selecting the representative households used for this study. Three Local Government Areas in the Niger State namely Mokwa, Mashegu and Paikoro from the three Agricultural zones were selected randomly in the first stage. Simple random sampling were used to select twelve (12) rural settlements from the wards selected in the second stage. The last stage was the selection of household heads from the chosen settlements. 240 respondents were drawn from the chosen settlements proportionate to size. Descriptive statistics such as frequency distribution, means and percentages were used to achieve objectives I and II.

Model Specification

Food security line

Household's expenditure on food which has found wider application in several empirical studies (Omonona and Agoi, 2007; Bamou and Mkononga, 2008; Iheke and Arikaibe, 2012) were used to achieve objective III. The food security line was estimated as two-third of mean per capita monthly expenditure of all respondents. Households were then classified into their food security status as food secure and food insecure households based on the food security line.

The formula is given as;

$$FSi = \frac{\text{per capta food expendture for the th household}}{\frac{2}{3}\ \text{mean per capta food expndture of all households.}}$$

Where;

FSi= food security index

FSi ≥ 1 food secure ith household.

FSi < food insecure ith household. …………………… (1)

A food secure household is that whose per-capita monthly food expenditure is above or equal to two-thirds of the mean per-capita food expenditure, while a food insecure household is that whose per-capita monthly food expenditure falls below two-thirds of the mean monthly per-capita food expenditure.

Binary logit regression model

Following Adeniyi and Ojo (2013), a binary logistic regression model was used to examine the determinants of household food security of the respondents in the study area. The food security status of households which is bivariate, taking the value of 1 for food secure households and 0 for food insecure households was used as the dependent variable. Socio-economic variable as well as food security indicator variables were used in the Logit regression analysis and specified explicitly in the model as:

$$FSi = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + 10X_{10} + U \ldots \quad (2)$$

Where;

FSi = Food security index (ratio)

β_0 = Constant

X_1 = Age of the household head (years)

X_2 = Gender of the household head (Male=1: Female=0).

X_3 = Marital status of the household head (Married=1: Single=0).

X_4 = Household size (Number).

X_5 = Educational status of the household head (Number of years).

X_6 = Number of income generating activities (Number)

X_7 = Quantity of own production (kg grain equivalent)

X_8 = Membership of cooperatives (Yes=1: No= 0)

X_9 = Remittance (1= if they receive in cash or kind. 0 = otherwise)

X_{10} = farm size (Ha)

U= Error term

RESULTS AND DISCUSSIONS

Socioeconomic Characteristic of Farmers in the Study Area

The findings from the field survey reveal some personal and household characteristics of the respondents in this study are presented in Table 1. Results in Table 1 show that majority (36.7%) of the respondents were within the age group of 26 – 35 years with mean age of 38 years. This implies that the respondents were in their active and productive age where they could diversify into off-farm income generating activities to improve their livelihood. This finding is in agreement with that of Odoh and Nwibo (2017) who reported that the majority of household in South-Eastern Nigeria that diversified into off-farm income are younger and active in their respective occupations. That greater proportions (68.8%) of respondents were male whiles (31.3 %) were females. This implies that male are the dominant gender in off-farm activities in the study area. This could be due to the fact that they are major decision makers regarding off-farm income generating activities. This agrees with the findings of Okere and Shittu (2012) who revealed that the males dominated the work force in Nigeria's agricultural communities. Majority (40.2%) of the respondents had household size of less than 11 people with a mean household size of 7 people implying a relatively large household size which is very important in agricultural production. This result agrees with the findings of Okere and Shittu (2012) who posited that larger households are likely to diversify into off-farm income activities than smaller households.

Years of farming experience reveals tha (22%) of the respondents had farming experience between > 21 years with a mean of 12.5 years of farming experience. This implies that the small-scale crop farmers in the study area are relatively experienced and exposed to various forms of off-farm activities that could enhance income and livelihood. This finding is in consonance with that of Babatunde and Qaim (2009) who reported that highly experience farmers diversified into non-farm income activities in Nigeria. Also More than half (30%) of the respondents had farm size between 1.1 – 2 hectares with a mean of 2.1 hectares. This implies that the respondents are actually producing crops on a small-scale. This finding agrees with that of Adeoye *et al.* (2019) who reported that larger proportion of households in Nigeria operate on small scale.

Table 1: Distribution of respondents according to socioeconomic characteristics (n=240)

Variables	Frequency	Percentage	Mean
Age			
< 26	30	12.5	37.8
26 – 35	88	36.7	
36 – 45	71	29.6	
46 – 55	38	15.8	
> 55	14	5.4	
Sex			
Male	165	68.8	
Female	75	31.3	
Marital status			
Married	201	83.7	
Single	25	10.4	
Widowed	10	4.2	
Divorced	4	1.7	
Household size			
< 6	97	40.4	7.0
6 – 10	96	40.0	
11 – 15	32	13.3	
> 15	14	5.8	
Educational status			
Adult	27	11.2	8.9
Primary	53	22.0	
Secondary	59	24.5	
Tertiary	35	14.6	
None	66	27.5	
Farming experience(yrs)			
< 6	56	23.3	12.5
6 – 10	50	20.8	
11 – 15	40	16.7	
16 – 20	42	17.5	
> 21	52	21.7	
Farm size(ha)			
< 1.1	66	27.5	2.1
1.1 - 2.0	72	30	
2.1 - 3.0	65	27.1	
3.1 - 4.0	22	9.2	
> 4.0	15	6.3	

Source: Field Survey, 2023

Distribution of Respondents Based on Livelihood Activities

The results of this study shows that many rural areas in Niger State and Nigeria, different households had highly diversified income-generating activities. From the findings, different farming and non-farming income livelihood activities of household heads were identified. However some of the activities identified in the study area are presented in Table 2 and 3 as farming and off-farm/Non-farm activities respectively. They are classified into four groups namely; farming, trading, skilled non-farm, and low skilled non- farm activities. In all the settlements, it is evident that farming is the most important livelihood income source as all households participate in farming on a commercial and or subsistence basis. The result shows that majority of the respondents 58.3% are into crop farming while livestock rearing has 33.3% participation rate with fishing farming having 8.3%. This finding is in line with those of Arene and Anyeaji (2010) and Oni and Fashogbon (2013) who said that, rural Nigeria is characterized by small scale agrarian livelihood as well as certain other primary production activities. Low skilled off-farm/non -farm activities is the second largest activity with about 43.57% participation rate. It represent a very low cost, low return niche occupied by respondents with very low human capital accumulation in either formal education or vocational training. Activities that fall under this category include artisans, motor cycle transport (Achaba), casual wageworkers or labourers and all other menial tasks. Skilled non- farm activities refer to occupations for which requisite training is received by the respondents in the form of formal education or vocational training, which could be in the formal or informal sector. It encompasses the range of occupations found among the respondents, which includes civil service, carpentry, masonry, mechanic/electricians, photography, clergy, blacksmithing, and sewing. This category is ranked third among the respondents having a participation rate of about 20%. Trading is the least among the categories of activities with about 12.14% participation rate. This can be attributed to the fact that most of these settlements do not have functioning markets couple with their low population and other constraints.

Table 2: Distribution of Respondents According to their Farm Activities

Activity(ies)	Frequency	Participation Rate (%)
Crop farming (wet and dry season farming)	140	58..3
Livestock farming	80	33.3
Fishing farming	20	8.3

Source: Field survey, 2023.

Table 3: Distribution of Respondents According to their Off-farm/Non-farm Activities

Activity (ies)	Frequency	Participation Rate (%)
Hunting	26	8.3
Ox drawn ploughing	06	2.5
Sales of Wild fruit	08	3.3
Spraying of herbicide	04	1.7
Barbing	05	2.1
Beer Brewing/sale	05	2.1
Blacksmithing	13	5.4
Butchery	06	2.5
Car driving	13	5.4
Carpentry	3	1.3
Casual labour	26	10.8
Charging/Recharge card sales	03	1.3
Civil Service	20	8,3
Clergy	05	2.1
Drug sales	07	2.9
Firewood gathering	08	3.3
Grinding Mill Operation	08	3.3
Motorcycle transport (*Achaba*)	10	4.0
Oil pressing	06	2.1
Photography	05	2.1
Pottery	05	2.1
Retail shop (kiosk)	06	2.5
Sale of Thatch	12	5
Sand packing	10	4.2
Sewing	08	3.3
Traditional herbal Practice	06	2.5

Vulcanizing	02	0.8
Wood carving	10	4,2
Total	**240**	**100**

Source: Field survey, 2023

Food Security Status of the Respondents

Food security index estimation using expenditure method was used to classify the respondents into food secure and food insecure households in a bid to establish the food security status of the individual households. This is shown on Table 4. A food secure household is therefore, that whose per capita monthly food expenditure is at least two-third of the mean per capita monthly food expenditure. On the other hand, a food insecure household is that whose per capita monthly food expenditure is less than two-third of the mean monthly per capita food expenditure. The mean per capita food expenditure per month was estimated to be ₦12,588.12 and this value was used as food security index. The food security line was ₦6,235.07. This implies that, all respondents whose per capita monthly food expenditure falls less than ₦6,235.07 was regarded as being food insecure. This is because; it is an indication that these households were unable to meet their expectedfood expenditure. Respondents with values equal or above ₦6,235.07 are regarded as beingfood secure. The findings on Table 4 indicates that 68% of the respondents were food secure while 31% were food insecure. This implies that, the incidence of food insecurity among the respondents is high and this is in agreement with the findings of Adepoju and Adejere (2013) who reported that, there is high incidence of food insecurity in rural Nigeria with North East sub-region having about 56% food insecure households.

Table 4: Distribution of Respondents According to Food Security Status

Food Security status	Frequency	Percentage (%)
Food Insecure	75	31,3
Food Secure	165	68.7
Total	240	100

Source*: *Field survey, 2023

Households' own perception of food security status

Table 5 showed the perception of the respondents to food security. They were asked whether their own households had sufficient food between the previous year and now. The result indicated that majority 67.7%) of the respondents were of the view that they had enough food during the period. However, 33.3% of them felt their household had food security problem during the period. This finding has an important implication as it shows the presence of transitory or even chronic food security challenge among the study population.

Table 5: Households' Own Perception of Being Food Secure

Perception	Frequency	Percentage (%)
Yes	160	67.7
No	80	33.3
Total	240	100

Source*: *Field survey, 2023

Determinants of Household's Food Security of the Respondents

In explaining the determinants of food security among the respondents, the Binary Logic regression model used gave results of the parameter estimates of these variables as presented in Table 6. The model gave the McFadden R-square as 0.617, which impliesthat all the explanatory variables included in the model were able to explain to about 62% of the variability in food security status of households in the study area. The variables that were found to significantly influence food security status included; household size, educational status, number of income generating activities, remittance and farm size.

The finding reveals that household size (X_4) has a coefficient of -0.1673 and significant at 5%. This implies that there is an inverse relationship between household size and food security. In other words, an increase in family size would lead to a decrease in household food security status. Specifically, a member increase in household size decreases the probability of household being food secure by 0.1673. This is in agreement with Ikpi and Kormawa (2004), Haile *et al.(*2005), Adebayo (2012), Bashir *et al*. (2012) and Adepoju and Adejere (2013) who found that an increase in one family memberincreases the chances of a household becoming food insecure by indirectly reducing income per head, expenditure per head, and per capita food consumption. This may be attributed to the fact that household size exerts more pressure on consumption than it contributes to production (Paddy, 2012). The coefficient of years of formal education (X_5) is statistically significant at 5% level and has a positive relationship with household food security. Specifically, the probability of being food secure is increased by 0.6255 for households whose heads had higher level of formal education. This suggests that, increase in years of formal education increases the likelihood of households to be food secured and vice versa. This is asexpected, since the level of education should positively affect the income earning capacity and level of efficiency in managing the household's food resources. The result coincides with those of Omonona *et al*. (2007), Asogwa and Umeh (2012), Adebayo (2012), Adepojuand Adejere (2013), and Oni and Fashogbon (2013**)**. The coefficient of number of livelihood activities (X6) of household is statistically significant at 1% and exhibits a positive relationship with food security status. This impliesthat, increase in the number of livelihood activities increases the possibility of a household becoming food secure by 0.3495. Therefore, households involved in diverse activities tend to be more food secure than those who are into fewer activities. This is because diversification is one of the livelihood strategy that provides additional income to rural household. It enhances household economy and food security by giving additional income and decrease food deficit when agricultural production falls short and also minimizes the sales of farm produce that should be consumed. Alternative income sources outside farming provide enhanced security for household livelihood. This is in line with the *a priori* expectation and the findings of Joshi *et al*. (2004), Babatunde and Qaim (2009), Aidoo *et a*l. (2013), Awotide *et al. (*2012), and Frimpong and Asuming-Brempong (2013).Remittance (X9) has a positive and statistically significant (5%) relationship with food security. This signifies that for a unit rise in transfer income, the level of food securitywill increase by 0.001768. This implies that, an increase in the amount of transfer increasesthe possibility of a household becoming food secure. This is due to the fact that remittancescontribute to household income and would lead to increase per capita food expenditure andconsequently improved food security status of the households. This finding corroborate those of Asogwa and Umeh (2012) and Adepoju and Adejere (2013) who revealed that, households with access to remittances have a lower probability of being food insecure. The coefficient of farm size (X10) was positive and statistically significant at the 1%level. This means that as a household's farm size increases, food security tends to increase. Specifically, the probability of being food secure increases by 0.8621 for every hectare increase in farm size. That is, households with larger farm sizes tend to be more foodsecure than those with smaller sizes, and vice versa. This can be attributed to the greater efficiencies in the use of resources associated with the large farms than those with small farms as observed by Reddy *et al.* (2004). Consequently, small farm holdings may result tolow productivity, low income, and the incidence of food insecurity among the farm households. This outcome is consistent with the finding of Asogwa and Umeh (2012) who opined that household food security increases with increase in area under cultivation.

Table 6: Result of Logit Regression for the Determinants of Household Food Security inthe Study Area;

Variable	Coefficient	Std. Error	z-Statistic
Age(X1)	-0.040866	0.026334	-1.551860
Gender(X2)	-0.533513	1.244779	-0.428601
Marital status (X3)	0.702810	1.271306	0.552825
Household size (X4)	-0.167331	0.079058	-2.116551*
Education level (X5)	0.625480	0.309489	2.021006*
Livelihood Activities (X6)	0.349534	0.089090	3.923383**
Coop. membership (X7)	0.000124	0.000125	0.990255
Quantity of produce (X8)	0.056035	0.393834	0.142280
Remittance (X9)	0.001768	0.000708	2.496584*
Farm size (X10)	0.862143	0.159159	5.416855**
C	2.183095	1.292364	1.689225

Source: Field Survey, 2023

Note: ***implies significant at $p<0.01$, **implies significant at $p<0.05$, *implies significant at $p<0.1$

CONCLUSION AND RECOMMENDATIONS

From the result of this study, it shows that participating in diverse livelihood income activities have an important influence on household food security status. The analysis and findings in this study have shown that food insecurity is a problem in the study area as measured and also opined by the respondents. Similarly, the respondents have shown great interest to diversify their livelihood sources, but are constrained by many factors. Hence, the need to assist these rural residents to overcome these constraints so as to promote remunerative and also diverse livelihood income activities which will in turn improve their food security status.

The preceding analysis has brought out some findings that have important implication on policy formulation. Based on these findings, the following recommendations are proffered towards promoting diverse livelihood income activities and food security in the study area:

i. To address the resource acquisition constraints faced by the respondents, there is the need for rural development actors to improve access to credit by rural farmers. Innovative micro-credit packages should be introduced so as to promote remunerative livelihood income activities. Such initiative should be self-sustaining and whose savings and loan schemes are organized to suite rural residents.

ii. In order to encourage diverse livelihood income activities, it is important that development actors focus on providing basic infrastructure such as electricity, good access roads, portable drinking water, health facilities, schools among others. Such infrastructure has an immense potential to facilitate improved rural livelihoods and poverty reduction through promoting integration with national economies, transfer of information, efficient markets, improving the working mobility of people, resources and outputs.

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WHY AGRICULTURE FAILS IN THE DEVELOPING NATIONS: THE CASE OF POVERTY, PROSPERITY, HUNGER AND FOOD INSECURITY IN NIGERIA

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ABSTRACT
Food security is a basic human need and its absence can lead to hunger and poverty in any developing country, in 2015, the number of people living in hunger in Nigeria seemed to be declined but started increasing gradually from 2016 till date. Today, two billion people are still living in severe food insecurity and this implies that 820 Million of these two billion facing food insecurity are living in hunger and poverty. A nation is said to be prosperous, once it is able to make environment conducive and a sustainable atmospheric standard of livings among the citizens. The prosperity of a nation must be in line with its Social Progress Index (SPI) that measures the extent to which countries provide for the social and environmental needs of their citizens. This implies that the ranking should be based on wealth, economic growth, education, health, personal well-being, and quality of life obtainable in the country. National prosperity is a man made and not inherited. It does not only grow out of a country's natural endowments, its geography, labour pool, interest rates or its currency's value, as some scholars suggested. National prosperity is created from the efficiency and transparency of the people living in a country. In view of this, this paper holistically looked into why agriculture fails in the developing nation like Nigeria. In the course of the study, the research found that agriculture collapsed in Nigeria due to the followings: Conflicts, natural disasters, policy inconsistencies, corruption, political institutions and leadership system, gender inequality, noninvolvement of farmers in policy-making processes, death of infrastructures, poverty and hunger, ineffective career guidance, poor marketing and media relation, climate change and deterioration in science and technology. In the light of these, it becomes very obvious that agriculture has been neglected and needs to be addressed in terms of straightening the key roles of agriculture in eliminating poverty, hunger and rural development, ensuring access to agricultural inputs through comprehensive approaches to affordable prices, prioritization of equitable development and gender equality in agriculture, embracing sustainable agriculture through climate sensitive, investments in agriculture and revival of agricultural sector, reinforcing resilience to disasters and application of biotechnology in agriculture.
Keywords: *Good governance, agricultural growth, investment, poverty, food insecurity*

INTRODUCTION
Nigeria as of today depends heavily on oil sector for her economic growth and this imposed illusions on the citizens' mind that government relying highly on oil income to take care of various problems in Nigeria is possible (World Bank, 2020). Because of this, agriculture that supposed to be the major contributor to Nigeria's economic growth has been relegated and sidelined. Agriculture is the source of income for many Nigerians before the advent of oil boom. Despite being an overall rich country with oil assets, Nigeria's economy has not provided more job opportunities ,except only a few people that benefit from it (World Bank, 2019).However, about 96 million people and 48%, of the population are extremely poor (Otekunrin *et al.*, 2019; World Poverty Clock, 2020). Since the population is growing geometrically and the percentage of people living in poverty is changing drastically, the accurate number of people in poverty is increasing geometrically as well, and this causes more people to suffer from food insecurity (Ugwoke *et al.*, 2020).

In November,1996 World Food Summit held in Rome, all heads of government and their representatives at the summit were supported and agreed to achieve global food security and alleviation of hunger with the aim of reducing the population of undernourished persons by the year 2015 (Matemilola and Elegbede, 2017). Despite this development by international institutions, the population of the undernourished people in the world remains a major problem in most parts of the world especially in Africa. According to 2015 assessment of the Food and Agriculture Organization of the United Nations (FAO), around 795 million people in the world remained undernourished and the figure represents 167 million and 216 million reduction in the last decade and 1990 respectively (Matemilola and Elegbede, 2017).

According to World Bank (2019), development of agriculture remains one of the most effective tools to end extreme poverty, boost prosperity and feed a projected 9.7 billion people by 2050. To meet the demand, agriculture in 2050 will need to produce almost 50 percent more food, feed and bio-fuel than it did in 2012 (FAO, 2017).Agricultural productivity in Sub-Saharan Africa has continued to fall short of expectations. Stagnant production growth and sharp annual fluctuations in output have been the chronic problem of developing economies, hence constituting the main cause of their persistent poverty and rising of food insecurity in the continent. In the light of this, Etuk,and Ayuk (2021), cited that significant progress in promoting economic growth, reducing poverty and enhancing food security cannot be achieved in developing economies without strategically developing fully the productive capacity of the agricultural sector.

Sequel to the above, food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (Matemilola and Elegbede, 2017). From this definition, four components of food security emerged: availability, access, utilization and stability of food. Therefore, for a country to be food secured, all the four components must be satisfied simultaneously to meet the objectives of food security. Putatively, our economy is in a mess today because we lost what it takes to be great than what it takes to be a minority in the social system. Agriculture, which is the pillar of all nations and the root of all products on earth, has seriously been neglected because of oil exploration and pseudo democracy. For this country to cure her problem and be free from incessant economic recession, agriculture should be prioritized as our major source of income. In the light of the above, it behooves this study to do an analytical review on why agriculture fails in the developing nations: the case of poverty, prosperity, and hunger and food insecurity in Nigeria.

The Collapse of Nigerian Agriculture in the 21st Century

Many factors could be associated with the collapse of agricultural sector in Nigeria but the most important ones are highlighted as follows:

Conflicts: The ethnic or religious conflicts imposed devastating effects on agriculture, especially in the areas that are prone to conflict. Agricultural sector like other sectors in an economy requires security. This is not only essential but is critical because it can discourage development. However, one of the strongest and recently recurring factors that seem to threaten agriculture productivity in Nigeria is the state of insecurity in the country. Local or foreign business investors are not motivated to invest in an unsafe and insecure environment (Okonkwo *et al.*, 2015).They look forward to both high returns in investments and a safe environment for their investment. In the view of this, security is freedom from danger or threats to a nation's ability to protect and develop itself, promote its cherished values and legitimate interests and enhance the well-being of its people. It connotes protection against all forms of harm whether physical, social, environmental, political, economic or psychological and safety from all forms of harmful disruptions to peaceful coexistence (Umaru *et al.*, 2015). It will be wrong to say there is peace in such a country like Nigeria where Boko Haram and other sects are threatening the unity of the country (Anwana *et al.*, 2019).

Natural disasters: Frequent climate changes such as shortage of rainfall, drought, flooding, excessive rainfall and flood in some regions of the country contributed immensely to low food production in Nigeria and this may serve as a threat to agricultural growth in Nigeria.

Policy inconsistencies and corruption: Frequent policy summersault and poor performance of legislators assigned to implement food and agriculture policies impose serious setback on food production and agricultural growth in Nigeria. Once a new government assumes power, the previous agricultural policies and programmes are abandoned and new ones are put in place; not that the new ones are better than the old ones but it is in a bid to create opportunities for embezzlement. However, abandonment of some of the past programs like Operation Feed the Nation, Green Revolution, River Basin Development Authorities (RBDAs) as well as agencies like National Agricultural and Land Development Authority (NALDA) and the Directorate of Foods, Roads and Rural Infrastructure (DFRRI) have led to low agricultural and food productivity in Nigeria.

Political institutions and leadership system: Leadership, whether bad or good, must reflect either negatively or positively on a state's socioeconomic and political environment. Good governance has been equated to the realization of sustainable human development. It was seen as the bedrock of all development initiatives and fundamental steps to any form of sustainable growth in the country. As a result of bad leadership in Nigeria, most of our leaders have no sense of commitment to development. Our politicians lacked vision of development to improve the efficient resources they inherited. They were interested in access to power and privileges but not development. Lack of continuity and frequent change of government policies among politicians affect the nation's agricultural sector. Several attempts had been made to encourage productivity in the agricultural sector, but the frequent changes in government and subsequent government policy changes reduced agriculture finally to its knees. Various governments in Nigeria to address agriculture and rural development problems have adopted many strategies; the story remains the same due to rapacious nature of our politicians. Based on this, there are still inequality and poverty particularly in the rural areas and this constitutes a threat to Nigeria's vision of becoming one of the twenty strongest economies (Tiri *et al.*, 2017).

Gender Inequality: Gender inequality is one of the major challenges in agricultural sector. In some countries of the world, women have less access than men to agricultural assets, inputs and service do. However, agricultural crops are gender-specific in some communities, women do not have access to land owing to their culture and this imposes danger to agricultural growth in Nigeria. Based on this, analysts were of the view that, if women grant the same access to productive resources as men, women would have boost yield by 20 – 30 percent, raising the overall agricultural output in developing countries by two and half to four percent, this could lessen the number of hungry people in the country. Therefore, balancing gender inequality and recognizing the contribution of women to agriculture is essential to achieving global food security, and this proves the evidence that when the status of women is improved, agricultural productivity increases, poverty is reduced and nutrition improves (Anwana *et al.,* 2019).

Non-involvement of farmers in policy-making processes: Farmers need to be part of dialogues focusing on agricultural policies. If we acknowledge their vast population dynamics, surely, we need to include them in the formulation and implementation of policies affecting their future. More so, there is also a need to look into new policies that best reflect the current economy and agricultural practices as regards to current climate change; this replaces the needs to be invested in the implementation of some policies as in some instances that may not see the light of the day (Udemezue, 2019).

Dearth of Infrastructures: Rural areas are some times more deficient in physical and social infrastructure than urban areas; this may lead to rural-urban migration with the attendant removal of youths from the rural areas where agriculture is mostly practiced. As long as urban areas offer a more attractive destination for young people's desired lifestyles, more youths will continue to leave the rural areas. Availability of good roads, constant electricity, recreational facilities, internet, potable water, affordable housing and qualitative healthcare in rural areas will go a long way in retaining youths in rural areas and improving their engagement with agriculture, if properly rehabilitated (Udemezue, 2019).

Poverty and hunger: Poverty begat hunger and hunger is a barrier to economic development because it prevents people from working hard to increase productivity. Agricultural productivity is capital and labour intensive. The poor peasant farmers, due to their level of poverty, produce the bulk of food needs in Nigeria and they find it very difficult to care for themselves and their family members, let alone getting the necessary inputs and energy to produce for others. Because of this, the growth of a sustainable agriculture in the developing country like Nigeria may be threatened.

Ineffective Career Guidance: The absence of effective career guidance in schools is one factor that derails youth participation in Agriculture. The poor promotion of agriculture in schools as a tertiary study unit is another key component that shifts the minds of the youths from agriculture. Therefore, institutions that promote agriculture need to hold career expos in rural and urban settings to promote agriculture as a study unit, they need to make electronic and print media available to the youth. To promote the growth of agriculture in Nigeria there should be effective career guidance among youths, awareness should be created telling the youth that agriculture is a business on its own and not a punishment per say.

Poor Marketing and Media Relations: Another challenge is the poor promotion of agriculture. There is a need to create programming that makes agriculture to look cool and attractive to people. The internet, particularly, social media can also be good tools to promote agriculture if used effectively. With the surge of internet access among the youth, institutions promoting agriculture need to acknowledge the youth's shift from traditional media especially newspapers. Nowadays, most young people get their information from the internet so the internet would be one of the best platforms to market and promote agriculture to reach the youth demographically (Udemezue, 2019).

Climate change: Climate change is a general issue that affects every country in Sub-Saharan African States. In the year, 2012, there was one of the worst floods in Nigeria and this led to the loss of many lives, displacement of people, and farmland being washed away (Nkechi *et al.*, 2017; Kralovec,2020). In the year, 2022 the same incidence reoccurred and claimed lives and properties. Therefore, climate change does not affect all States at the same time. Nigeria has four different geographical climate zones: 'the warm desert climate in the Northeast, the warm semiarid climate in the other parts of the North, the monsoon climate in the Niger-Delta, and the tropical savannah climate in the middle belt and parts of the southwest' (Akande *et al.*, 2017). Rainfall is low in the North and high in the South, which leads to shorter rain seasons and desertification in the North and floods in the South. The coastal area in the South has furthermore to deal with the sea level rise. However, all in all, the North is more vulnerable to climate change. Desertification coupled with too much rainfall can lead to damages in cultivation and displacement of people. Therefore, the whole country is hit by climate change (Abdulkadir, 2017; FAO, 2017; Kralovec, 2020).

Deterioration in Science and Technology: In Africa and other third world countries, Nigeria inclusive, agricultural technologies are in constant deterioration and stagnation due our build and collapse mentality syndrome, which has long been identified as one of the reasons for poor agricultural production performance in Africa. It has been observed those indigenous techniques like crop rotation and other cultural farming practices, which have been used to maintain the soil structure and its fertility do not seem to be enough in the current efforts to boast food production in most developing countries to meet up with population increase. This calls for application of science and technology to promote agricultural production in Nigeria.

The Origin of Poverty, Prosperity and Hunger in Nigeria

The state of agriculture and its prosperity in Nigeria today is in shambles. It is nothing to cheer about and this has led the country to the level of importing millions of metric tons of food such as rice, wheat, floor, vegetable oil, beefy, chicken, fish, among others from foreign lands,. In spite of great potentials in agriculture (Dangana, 2011). Food security is a basic human need and its absence can lead to hunger and poverty in any developing century like Nigeria (Kralovec, 2020). According to FAO *et al.* (2019), in 2015, the number of people living in hunger declined but has started increasing from 2016 till date. Today, two billion people are still living in severe food insecurity, since they do not have regular access to food, and this implies that 820 Million of these two billion facing food insecurity are living in hunger and poverty (FAO et al., 2019).

Poverty refers to as before not having enough resources to provide the necessities of life such as food, clean water, shelter and clothing. However, looking at the things of modernity, it can be extended to lacking access to health care, education and security. Poverty could be seen as absolute poverty or relative poverty depending on the metric used by each country. Based on this,World Bank uses a metric called the International Poverty Line ,as of 2015, world bank set the definition of extreme poverty as those who live on less than US$1.90 per day while those living on between $1.90-$3.10 per day are classified as the moderate poor. This figure is based on the monetary value of a person's consumption rather than income alone. Common perceptions of poverty consider income and consumption alone but there are other significant factors that should be considered since money does not tell the whole story about what poverty is. Poverty goes beyond not having enough money to solve problems. It could be seen using the Multidimensional Poverty Index (MPI) and the Human Development Index (HDI) approaches. Based on these, poverty can be measured across three dimension such as health, education and standard of living. According to the World Poverty Clock, the population of Africans living in "extreme poverty" per continent is 430.3.As of 2023, the three countries with the greatest number of people living in extreme poverty are: Nigeria (71 million), Democratic Republic of Congo (68 million) and India (44 million) (*Charizze and Judy, 2023*).

At the societal level, high poverty rates can be a damper on economic growth and be associated with problems like crime, unemployment, urban decay, education, and poor health. This could be the reasons our youths engaged in various criminal activities to sustain their livings. To address the issue, governments often put social welfare programs in place to help lift individuals, families, and communities out of poverty (James, 2023). Therefore, a poor nation is not prosperous because it assumes poor in all ramifications, which could be because of its political institution or ideologies. Sequel to this, a nation is said to be prosperous, once it is able to create a conducive environment and a sustainable atmospheric standard of livings among the citizens. The prosperity of a nation must be in line with its Social Progress Index (SPI) that measures the extent to which countries provide for the social and environmental needs of their citizens. This implies that the ranking should be based on wealth, economic growth, education, health, personal well-being, and quality of life obtainable in the country. According to Olufemi (2022), national prosperity is a man made and not inherited. It does not only grow out of a country's natural endowments, its geography, its labour pool, its interest rates or its currency's value, as some scholars suggested. National prosperity is created from the efficiency and transparency of the people living in a country. This reminds us that Prosperous nations are not those with large populations or small populations; they are not those endowed with natural resources but those which can use their population, irrespective of the size,(whether small or big), and natural resources to increase the efficiency of the people through research and development to maintain a lead. However, two types of economy are essential to national prosperity :(a) Knowledge economy and (b) Agrarian economy. (a) Knowledge economy or advanced economy describes the use of commodity and economic value derived from research and development.(b)Agrarian economy is an economy which is highly dominated by primary industries like farming, fishing, lumbering, etc and subsistence means of production. Therefore, wealth of a nation depends on the type of the above economy used by a country. What makes the difference between wealthy and poor nations is how they are able to organize their factors of production to generate wealth (that is, how they are able to develop their land, entrepreneurs, capital and machinery to create wealth).

A nation can prosper through the exploitation of comparative advantages. In this case, differences in national values, geographical location and culture in the world can be exploited to develop the wealth of nations. According to Olufemi (2022) no nation with over 40 per cent youth unemployment rate, as can be seen in most African countries, can prosper. Government has to add to the value chain of the nation by helping the people to be able to fend for themselves and this is done by exploiting nations' comparative advantages. In Africa, some nations have comparative advantages in agriculture and our government should see it as comparative advantages for means of employment generation and national prosperity. Contrary to this, Acemoglu and Robinson (2013) pointed out that economic prosperity of a country is not determined by geography and culture as pointed above, but rather a matter of institutions and politics.

According to them, "Countries rise when they put in place the right pro-growth political institutions and they fail—often spectacularly—when those institutions ossify or fail to adapt. Powerful people always and everywhere seek to grab complete control over government, undermining broader social progress for their own greed. Keep those people in check with effective democracy or watch your nation fail."

Sustained economic growth in countries with extractive institutions is never possible, because elites limit access to economic institutions for a large part of the population. Sustained growth requires innovation, and elites generally oppose this, as it may threaten their economic and political prerogatives. Moreover, conflicts will inevitably arise between different competing elite groups that will destroy economic growth (Acemoglu and Robison, 2013).Temporary economic growth, is possible under extractive institutions, due to its clear limits. Sustained growth requires innovation, and elites generally oppose this, as it may threaten their economic and political prerogatives. Therefore, to have a sustained agricultural growth in Nigeria with extractive institution is hardly possible because income and wealth distribution are always related to the vicious circle, and this is done as to impoverish their citizens. In the agricultural sector specifically, one critical condition for growth is good governance structure and related policies at all levels. Therefore, unless effective governance systems are in place, agricultural reforms, food security, poverty reduction and development will remain a tall dream. Through institutional and human governance capacities, public policies and strategies effectiveness can be achieved and better public decisions are made and implemented (Anwana *et al.,* 2019).

To through more light on the nation's prosperity, Abraham Maslow's theory of needs states that human need are insatiable but predictable, and should be exploited by all nations at their benefit to increase their values. Human beings need food, water, shelter and clothing (psychological needs); security and safety of lives and properties, job security and environmental peace and order (safety needs); friendship, recognition, being loved and loving somebody (love and belonging needs); confidence (self-esteem needs) and fulfillment (self-actualization needs). This implies that we are motivated by the above needs as human beings. Therefore, if our basic needs are unmet, definitely, we would be unable to meet our societal needs. The constitutional role of every government is to ensure that everybody is psychological and safety needs are met but this is an opposite case in African continent. This theory is therefore used to justify why Africans are mostly not innovative and inventive, and why they remain poor (Olufemi, 2022).

Adam Smith on his book, usually referred to as The Wealth of Nations held that wealth was fixed and finite and that the only way to prosper was to hoard gold and tariff products from abroad. This theory was of the view that nations should sell their goods to other countries while buying nothing in return to have monopoly of trade. However, this could be impossible because no nation is an island on its own. To be specific, nations that want to create wealth and prosper must have surplus 'balance of trade' compared with other nations. Such a nation must be able to identify his areas of comparative advantage and judiciously develop these comparative-advantage activities to its benefit. Therefore, a nation like Nigeria with arable land should develop its agriculture to sustain agricultural growth, while a nation that has spiritual and religious history should develop its tourism potential. No nation can prosper by allowing its markets to be turned into dumping grounds and this interests us to know that without healthy competition with other developed nations, no nation can prosper.

According to World Bank reports, human development index in Africa is abysmal due to politics and corruption. Life expectancy is in the decline, poverty increases daily, death rate increases, decrease in standard of living and infrastructural designs are in dilapidation (Kuka, 2007;Udemezue *et al.,* 2017).everywhere in the world go today, Africans record failure in all spheres of life like political, economic, social and morally otherwise. Ideally, Africans should not be blamed in any political computation because; the continent is naturally blessed with oil and mineral resources. What could be the cause of our failure? Is it the way we play politics and corruption handlings that has placed us on the front lines food insecurity rating before the world. In view of these, our failure stems from bad governance and corrupt politicians that have inability to carry on the torch of independence and civilization, which was handed over to us through the founding fathers of our nations by our civilized colonial masters. The civilization, which they left behind for us, was the structure of governance and was at a time become inoperative and collapsed. With this, one can say that our problem is failure of leadership. Based on this, Ogara (2011), pointed out that the trouble with Nigeria is that it is governing by a breed of rapacious politicians, political vultures who impoverish the country and enrich themselves at the detriment of people. To his extension, there are two leaders in power; leaders committed to the common good and leaders derived by ambition and self-seeking. These two leaders behave according to their kindness and self-aggrandizement. Leaders in the first group are good and popular while those in the second group are bad and notorious.

As a matter of the above, our agricultural sector fails to grow just like other countries of the world simple because we have extractive politicians and not inclusive politicians that bring sustainable agricultural growth to the nation. Government institution in Nigeria is an extractive institution and not inclusive that carries everybody along in the affairs of government. For the country to be liberated from these shackles of leadership, all the political action committees must be duly dissolved, otherwise this may call for military inversion as have done in most of the African countries today. The question is who will bell the rat? This is subject to further research. Subject to these, Acemoglu and Robinson (2013) said that Inclusive institutions are institutions that safeguard not mainly the interests of the ruling elite, but which are open to larger groups in the society. These types of institution create incentives for people to save, invest, and innovate, while extractive institutions, on the contrary are institutions that harm the interests of the majority of the society because they aim to enrich only the ruling classes. In this type of institution, property rights are not sufficiently protected for most of the populaces, except for the elites who know that their interests are secured by force or power.

Bad governance has made development elusive in Africa and Nigeria in particular. Poor governance and corruption particularly in Nigeria has been responsible for the fall of the agricultural sector. The various river basins development authority and other agricultural establishments are not functional to supply food to the nation. They do not produce food, they are more or less exists, as bureaucracy where there are workers that receive salary every month, but the production of food is absent. However, those government establishments failed in Nigeria because of corruption and extractive politicians who keep their eyes open always to see where opportunity exists to divert money into their private pockets. Nigeria is in visible ruins and the results of these problems are reflecting in every sphere of our national existence. It is only the beneficiaries of these corruptions can see and say that the country is in the best shape while opposite is the case. Our leaders often deliberately offer a false image of peace, unity, stability, progress and development in the country through diplomatically deceptive speech as to outshine the eyes of other nations (Udemezue *et al.,* 2017).

Good governance and effective leadership are stepping-stones to sustainable development. Studies on the Nigerian economy have proven leadership problems as a major cause of the country's inability to mobilize her resources. Leadership problem has hindered the country's progress in the political, economic, military, socio-cultural sectors (Ogbeidi, 2012) .Nigeria's expectations at independence were high, and the possibilities for greatness were grossly assured. The leaders had a supreme confidence of greatness considering the vast resources endowed with, but with things of regret, the Nigerian economy has hit below the expectations because of massive underutilization of resources occasioned by bad governance. Leadership and lack of transparency in public spending have resulted in massive looting of the national treasury and gross mismanagement of public enterprises which this has led the nation into the arrays of agricultural failure and economic dwindling (Balogun *et al.,* 2021).There is an organic interconnection between quality of governance and capacity to drive a sustainable development. Good governance was seen as the bedrock of all development initiatives in a country and a fundamental prerequisite to any form of sustainable growth or meaningful development in the country (Balogun *et al.,* 2021). Concisely, what determine the prosperity of a nation and development are political institution, culture, history/linage, geography, economic resources, ideology and agriculture.

Agriculture remains an everlasting panacea to the well-being of Nigeria; this is because every nation has the responsibility to feed her citizens and any nation that cannot feed her citizens adequately is vulnerable to unrest and cannot have peace and stability. Therefore, for a nation to be able to feed her citizens, it must strengthen its agriculture and produce sufficient food. To do this, it requires a lot of inputs which only government has the resources to coordinate and provide (Udemezue *et al.,* 2017).Agriculture is the main root of economic building and whatever affects agriculture indirectly, affects economy directly. Therefore, the primary expectation of agriculture is to maintain the economic building of nation's development. However, diversification of Agricultural inputs and budgets made for agricultural production by corrupt government officials and politicians could cause poor building of Nigerian economy as well as agricultural failure thereafter.

Nigeria is not beyond redemption, let us put hands together and rebuilds this country from these ruins. In this case, this paper hereby advice leaders to enthrone good governance, ensure justice in the country and mobilize the teeming youths to harness their talents in national productivity and wealth generation. If leaders in Africa fail to stop looting of the countries common wealth, this continent will gradually be tamed by the angry youths to the level that there will be no hiding place for the rapacious leaders in Africa.

Way forward on enhancing agricultural growth in Nigeria

The basic approaches for enhancing agricultural growth and prosperity in the developing countries include the followings:

Straightening the key roles of agriculture in eliminating poverty, hunger and rural development: The roles of agriculture in nation building and poverty reduction have to be straightened there by empowering the smallholder farmers who are the major contributors to food production in the country. Provision of necessary support to raise rural incomes and productive capacities to enable smallholder farmers participate and benefit from national and international markets are prerequisite to agricultural prosperity in the developing countries.

Ensuring access to agricultural inputs through comprehensive approaches to affordable prices: Cost of agricultural inputs is so high that the majority of the farmers cannot afford them; this has led to migration of some youths from rural areas to the urban. Access to agricultural inputs will bring more hands into agriculture since the majority of our youths left the system not just that they lack interest, but because of the high cost of farm inputs. Based on this, government should therefore, subsidize agricultural inputs to be affordable by the farmers who are the end users of the products. This movement and initiative will not only boost food production but also enhance agricultural growth in a country.

Prioritization of equitable development and gender equality in agriculture: Equitable development and gender equality, especially empowerment of women since they are the most marginalized and vulnerable set of people in agriculture can reduce the menace of food insecurity that leads to agricultural prosperity in totality. More so, if women can give the same access to productive resources as men, agricultural yields and output would increase and there would be a significant reduction in the number of impoverished people. In the light of this, Akinyetun (2018) pointed out that there will be surplus food for the nation if women could be granted access to; and control over land and other productive resources; empowering women smallholder farmers to overcome institutional, social, and economic bottlenecks, and participation of both women and men in decision-making at all levels.

Embracing sustainable agriculture through climate sensitive: Climate change is one of the factors working against food production in the world today. Food demand in the world today increases because of population growth, urbanization, and changing dietary habits and this implies that greater attention should be given to some uncertainties in agriculture like climate change to sustainable agriculture. Sustainable intensification of agriculture requires increases in productivity, while adapting to climate change and reducing greenhouse gas emissions. Therefore, Climate-sensitive agriculture makes growth more sustainable, while improving the management of ecosystems, including soils, forests, water, fisheries, oceans, watersheds and biodiversity.

Investments in agriculture and revival of agricultural sector: Investments in agriculture and revitalization agricultural sector in Nigeria contribute to major societal benefits, including inclusive growth, and creation of decent jobs. Reasonable investment in agriculture can be strengthened starting from the recognition that the main investors in agriculture are the farmers themselves, engaging small producers and their organizations fully in the design and implementation of national strategies for agriculture and food security will help in regernerating the confidence of the farmers. Similarly, ensuring their land tenure system land and improving their access to improved technology and innovation, ensuring they benefit from key public goods such as market infrastructure, price stabilization instruments for both producers and consumers, affordable financial services, and functioning extension services. This calls for an integration of public and private investment that includes farmers' associations, agri-businesses, government, civil society groups and sources of financing.

Reinforcing resilience to disasters: Poor rural and urban farmers face challenges such as volatile food prices and climatic shocks that threaten their food price and productivity. However, the sustainability and resilience of their livelihoods can be reinforced through developing a range of capacities and entrepreneurial skills; promoting non-farm rural employment; empowering small producers to diversify their on-farm and off-farm activities; including the most vulnerable in sustainable development processes, and investing in social protection such as food assistance, safety nets and targeted transfers.

Application of biotechnology in agriculture: Biotechnology represents a scientific advance in agriculture with far reaching potentials in increasing food production in an environmentally sustainable manner. Agricultural biotechnology includes using genetics to modify crops and plants to produce more nutritious food, cloning of livestock; tissue culture technique and genetic engineering (Akinyetun, 2018).Therefore, application of it in our daily farming will help to boost agriculture in the country.

CONCLUSION

Bad governance has been a stagnant to agricultural development in Nigeria. Poor governance and corruption particularly in Nigeria has been responsible for the fall of the agricultural sector. In view of this, this paper holistically looked into why agriculture fails in the developing nation like Nigeria. In the course of the study, the research found that agriculture collapsed in Nigeria due to the following: Conflicts, natural disasters, policy inconsistencies, corruption, political institutions and leadership system, gender inequality, non-involvement of farmers in policy-making processes, dilapidated infrastructures, poverty and hunger, ineffective career guidance, poor marketing and media relation, climate change, deterioration in science and technology. In the light of these, it becomes obvious that agriculture has been neglected and needs to be addressed in terms of straightening the key roles of agriculture in eliminating poverty, hunger and rural development. Also ensuring access to agricultural inputs through comprehensive approaches to affordable prices, prioritization of equitable development and gender equality in agriculture, embracing sustainable agriculture through climate sensitive, investments in agriculture and revival of agricultural sector, reinforcing resilience to disasters and application of biotechnology in agriculture.

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RESOURCE USE EFFICIENCY OF CUCUMBER (*CUCUMIS SATIVA* L.) PRODUCTION AMONG SMALLHOLDER FARMERS IN SABON-GARI LOCAL GOVERNMENT AREA OF KADUNA STATE, NIGERIA.

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ABSTRACT
Cucumber (Cucumis sativa L.) is a nutritious crop whose production and utilization gives greater satisfaction for food security, employment and health needs of Nigeria. An average farmer achieved a gross margin per hectare of ₦2,680,580.00; incurred a total variable cost of ₦706,300.00 per hectare and had a return on investment of ₦3.64. R-square value of 88% which was significant at 5% level of probability showed that the regression coefficients of specified variables were significantly positive, less than unity, and thereby sufficiently explained the cucumber output in the study area. The resource use efficiency of cucumber production implied that fertilizer, labour and land resources were under-utilized while the one for seed resources were over utilized. The major constraints to cucumber production were inadequate storage facilities and inadequate water and irrigation facilities. The study recommended the deployment of more qualified and experienced extension agents for the farmers and the formation of farmers into cooperatives to build on their social capital values and to actively advocate and or solicit for government support.

INTRODUCTION
Cucumber (*Cucumis sativus* L.) is one of the exotic and refreshing vegetable crop in Nigeria. It is consumed as a healthy food and as a valuable source of conventional anti-oxidant food rich in vitamin C, beta-carotene and manganese (Sambou *et al*., 2023). Cucumber is low in cholesterol and sodium; and it is a rich source of prophylactic and therapeutic ingredient for daily bodily need (Suma *et al*., 2019). Furthermore, Cucumber was said to being consumed since ancient times, eaten as traditional food and used for treating constipation (Pan *et al*., 2022). Its consumption helps to maintain hydration, relieves constipation and helps to reduce the risk of cardio vascular diseases as well as many types of cancer (Mallick, 2022).
Cucumber (*Cucumis sativus* L.) belongs to the family of cucurbitaceae and is an important vegetable crop (Eifediyi and Remison, 2010). Cucumbers are long, cylindrical green fruits that contain about 95% of water, and are for this reason it is often recommended as natural diuretics and helpful for body building (Wilcox *et al*., 2015). The production of cucumber is complex and very technical in handling. It is a tender and frailly crop that requires serious management focus, attention and technology (Rahman *et al*., 2020) as one grows the crop from seedling to maturity. The commercialization of this crop therefore requires that farmers have requisite skills and resources to provide high cost of inputs such as irrigation, fertilizer, and labour in other to achieve surpluses (Rahman.*et al*., 2020) However, for farmers around water bodies and those that can afford small scale irrigation farming would possibly have considered this, as an adaptation strategy for coping with rainfall variations. However, the interruption of rains within growing season and the adverse effects of drought upon soil conditions render crop failure for most farming households that lives in rural areas in particular.
Cucumbers thrive best at relatively high temperatures, between 75 to 85 degrees F. The plants do not tolerate frost. Since they are a quick-growing crop, they must be well supplied with moisture and plant nutrients throughout the growing season. Water is especially critical for cucumbers during the fruiting stage. Cucumber plants like sun, but are prone to scorching, so some shade is preferable. Encourage greenhouse varieties to climb to boost yields. Harvest fruits early in the day while it's cool. Harvest frequently to get more fruits during the season. Along with seasonal production, cucumbers are also successfully grown in off season under greenhouse due to its suitability to thrive under high light intensity, high humidity, high soil moisture, temperature and fertilizers condition. Cucumber farming is considered as an essential part of agriculture and its noteworthy contribution in raising the foreign exchange earnings for Nigeria. In addition, since it's a labour intensive enterprise and thus offer a considerable promise for generating rural employment opportunities, especially for unemployed women and youth in the study area.

Among the vegetables in various regions of Nigeria, the most studied include tomato, pumpkin and watermelon, among others (Oguniyi and Oladejo , 2011; Adenuga *et al*., 2013; Ayinde *et al*., 2011; and Adeoye *et al*., 2011); only few studies existed on the resource-use efficiency of smallholder cucumber production in Kaduna state. Cucumber is one of the most important exotic vegetables in Nigeria. Its profile is rising due to widespread knowledge of its health benefits and to sustain the availability of the crop supply and meet with its increasing demand, there is the need to understand the economics of its production and resource use efficiencies as a way to understand achieving its productivity. This study avails itself to achieve in Sabon-gari LGA of Kaduna State, the following specific objectives are stated as follows: (i) analyze the costs and returns of cucumber production, (ii) estimate the input-output production function of cucumber production, (iii) estimate the resource use efficiency of cucumber production, (iv) identify problems encountered in cucumber production by farmers,

METHODOLOGY

The study was conducted in Sabon-Gari Local Government Area of Kaduna state of Nigeria; located in the Northern Guinea Savannah Zone of Kaduna state. The Local Government Area is situated on a plateau of a height of about 700m above sea level of latitude 110 12' N and longitude 70 8'E. The study area has two distinct seasons which are dry and wet seasons. The rainfall extends from April to October and average annually between 100 to 1000mm with a mean temperature ranging from 27.20 ^{0}C to 35 ^{0}C in the month of April. The local government area has an estimated population of farming families of about 246,544. It consists also of 12 Districts including Samaru, Jama'a, Bassawa, Hanwa, Dogarawa, Chikagi, Muchia, Zabbi, Jushi , Angwa-gabas, Angwan-godo and Bomo. The predominant language is Hausa and majority of the populace are Muslims. The major crop grown in this area includes Maize, millet, groundnut, cowpea, sugarcane, rice and vegetables such as cucumber, tomato, onion, and pepper are cultivated. The major livestock kept are goats, sheep, cattle and poultry. The farmers in the study area use simple farm implements such as hoes, cutlass and human labour mostly. The farm economy is characterized by small size and fragmented land holdings.

The study adopted a multi-stage cross-sectional sample survey design. The population of farmers involved in the study were Cucumber farmers in Sabon Gari Local Government Area of Kaduna state. The multistage approach used, firstly involved a random selection of 4 district/villages from the twelve district listed above. Secondly, a random selection of 30 farmers from each of the villages making a total of 120 farmers, who were actively involved in the cultivation of cucumber were selected and interviewed. A well-structured and pretested questionnaire, was administered by trained enumerators. The data collected include those of socio-economic characteristics of respondents, revenue and cost variables and of other factors affecting Cucumber enterprise in the study area.

The study employed descriptive statistic including use of frequency distribution, percentages and means to describe the socio-economic characteristics and constraints farmers faced in Cucumber production. Also, inferential statistic such as multiple regression analysis was used. The profitability of cucumber production was estimated on per hectare basis using farm budget techniques; including the estimation of gross return, gross cost, gross margin, net return and benefit-cost ratio (undiscounted). The formulas used for the calculation of profitability include: Gross return, GR = P×Q; where, P = Selling price of the product (Naira); Q = Yield per hectare (Kg). Total cost TC = TFC + TVC; where TFC = Total fixed cost (Naira); and TVC = Total variable cost (Naira). Gross margin, GM = GR – TVC. Net return, NR = GR – GC; and Benefit-cost ratio = Gross benefit / Gross cost. The production function and resource use efficiency of Cucumber production was carried out using Multiple Regression Analysis: - The model in its general implicit form is;

$Y = F\ (X_1, X_2, X_3, X_4, e_t)$; Where, Y = output of cucumber (kg), X_1 = Seeds (kg), X_2 = Fertilizer used (kg), X_3 = Labour input (man/hr) X_4 = Land (ha), e_t = error terms.

Among the functional forms tried, the best fit Cobb-douglas double-log form was used; and the explicit forms of the model is; $\log Y = a + b_1 log X_1 + b_2 log X_2 + b_3 log X_3 + b_4 log X_4 + e_t (Double\ Log\ ) \ldots\ldots\ldots\ldots Eqn\ 1$

The Resource-use efficiency, stated as; $r = \frac{MVP}{MFC} \ldots\ldots\ldots.. Eqn\ 2.$ Where, MVP = Marginal value product of a variable input, MFC = Marginal factor cost, r = Efficiency ratio. The MVP was estimated as follows;

$MVP = MPP.P_Y \ldots\ldots\ldots Eqn\ 3.$ Where, P_Y = Price of output, and MPP is the marginal physical product. The decision rule implies that; if r =1, resources are efficiently used. If r > 1, resources are underutilized, if r<1, resources are over utilized.

RESULTS AND DISCUSSION

Profitability of cucumber

The estimate of the costs and returns of cucumber production in study area was indicated in Table 1. below; and showed that an average cucumber farmer, growing cucumber on an average of an hectare of land, incurred a total variable cost of ₦706,300.00. He incurred a total cost of ₦ 728,800.00 which by breakdown consisted of; seed cost of ₦394,800.00 (54%), fertilizer ₦76,500.00 (10.5%), labour cost of ₦ 200,000.00 (27.4%), transportation cost of ₦ 35,000.00 (4.8%), Rent on land cost of ₦ 20,000.00 (2.7%) and Depreciation of farm tools costing ₦ 2,500.00 (0.3%). The cost items analysis indicated that cost of seed ₦394,800.00 (54%) was the highest percentage of cost of production used. This was so because cucumber crop is an exotic one in Nigeria, and the farmers have one-off use of the seed for planting. These hybrid seeds are packed in counts and in sachets of about 10g weight, being sold to farmers only by agro-allied companies like East-West Seed Company. Again, these seeds can only be planted, directly and or as transplanted seedlings raised from nursery beds. The cost of labour ₦ 200,000.00 (27.4%), was second in consideration owing to the fact that the crop needs intensive attention from land cultivation, to tendering the climber vines and plant on supports of strands or staking materials. Also, for cucumbers, harvesting activities are also not done as a one off activities, but rather, the crops are often harvested fortnightly throughout an extensive harvesting period; among others. Therefore, lots of man-hour was deployed. Also, the negligible percentage of depreciation cost (0.3%) revealed that most farmers are smallholders who uses simple and costless traditional implements in farming, rather than the use of capital intensive machinery that would have warranted a significant depreciation value. This justifies the use of gross margin in determining the viability of smallholder farmers in the study area (Olukosi and Erhabor, 2005). However, an average cucumber farmer is profitable in the study area with a gross margin of ₦ 2,680,580.00, and a Net farm income of ₦2,658,080.00. This is in line with Adeoye and Balogun (2016), they found that cucumber production was profitable among smallholder farmers in Oyo state, since their total cost of production was less than the total revenue obtained. Also, a return on capital of 3.65, was obtained by an average farmer, which implies that for every ₦1 invested in cucumber production, an average farmer gets back in return ₦ 3.65 only. Also, close result to Adeoye and Balogun (2016), found that the rate of return of cucumber production among smallholder farmer was 1.26, meaning for every ₦1 invested in cucumber production, ₦1.26 was obtained in return.

Table 1 – Estimated costs and returns per hectare for maize-groundnut production

S/n	Variables	Unit/ha (Kg/ha)	Unit price (₦/kg)	Value/ha (₦/ha)	Percentage (%)
1.	Variable Cost:				
a.	Seed (Kg/ha):	0.282	1,400,000.00	394,800.00	54
b.	Fertilizer (Kg/ha):	255	300	76,500.00	10.5
c.	Labour Cost (Man-hr/ha):	320	625	200,000.00	27.4
d.	Transportation (₦)	-	-	35,000.00	4.8
	Total Variable Cost (TVC)			706,300.00	
2.	Fixed costs				
a.	Rent on land (₦ / ha)	1	20,000	20,000.00	2.7
b.	Depreciation of farm tools (₦)	-	2,500	2,500.00	0.3
	Total fixed cost (TFC)			22,500.00	
3.	Total cost (TC)			728,800.00	100
4.	Total Revenue:	28,224	120	3,386,880.00	
5.	Gross Margin (GM)			2,680,580.00	
6.	Net farm income (NFI)			2,658,080.00	
7.	Return per capital (Naira) invested		(NFI/TC)	3.65	

Source; field survey, 2023

Production function analysis of cucumber production

The results of the multiple regression analysis presented in Table 2. Showed the variation in cucumber production among the farmers which was explained by some of the independent variables seed, fertilizer and labour costs included in the Cobb-Douglas model, in which they are positive and significant effects on cucumber output at 5%, 10% and 5% respectively, while the factor land was not significant neither at 5% nor 10%. This status was affirmed by an R-square value of 88% which implies that the independent variables actually influences the result of the dependent variable in the model. However, the result of input and output resources used were also as describe in Table 3, in which the mean values of input resource per hectare used, and the mean yield achieved by an average farmers was as indicated.

Table 2: Estimated co-efficient of Cobb-Douglas production function for cucumber farming

Variables	Regression Coefficient	Standard Error	t-value	Level of Significance
Constant	452.13	211.42	2.138	0.00
Log Seed (X_1)	0.734	0.234	3.137	0.01
Log Fertilizer (X_2)	0.616	0.443	1.391	0.05
Log Labour (X_3)	0.416	0.243	1.712	0.01
Log Land (X_4)	0.244	0.262	0.931	NS

Source; field survey data 2023.

R^2 = 0.88
Adj. R^2 = 0.76
F = 37.5
NS = Not Significant at 5% level of probability

Table 3 Description of input and output resources for cucumber production

Variable	Maximum	Minimum	Mean	Std. Deviation
Seed (Kg/ha)	0.35	0.23	0.28	4.50

Fertilizer (Kg/ha)	350	150	255	35.30
Labour (Man-hr)	345	112	320	155.20
Land (Ha)	1.23	0.32	1.1	0.71
Yield (Kg)	43,124	26,231	28,224	455.30

Source; field survey data 2023.

Resource use efficiencies in Cucumber production

The production function for cucumber production indicated the physical relationship between input and output as shown in Table 2 above. The resource use efficiency of cucumber production was determined as a ratios of marginal value product to marginal factor cost. All the resources used, except that of seed input, were greater than unity, Table 4; revealing that the resources were used at sub-optimal levels for cucumber production. The resource use efficiency for seed input was less that unity and thus, over utilized.

Table 4. Marginal physical and marginal value product for the inputs used in cucumber production

Input	MPP (Kg/Unit of input used)	MVP (₦)	MFC (₦)	MVP/MFC
Seed	20.82	202.4	212.2	0.95
Fertilizer	225	1452	987.3	1.47
Labour	320	2154	448.2	4.80
Land	1.05	19.3	12.4	1.55

Source; field survey data 2023.

Constraints to Cucumber production among smallholder farmers

Majority of the small holder cucumber producers' constraint in the study area was inadequate storage facilities (19.8%). They expressed that cucumber does not stay fresh for more than a week after harvest and thus, requires that, provision of adequate storage facility to farmers would go a long way to assist them balance the variation in market conditions after products'harvests; and thereby allow them make more profit and not always to lose out of business. This is in line with the report of Okonkwo-Emegha *et al*. (2019) that the cost incurred during the post-harvest contributes to low profit. Next in frequency of complaint by farmers is inadequate water and irrigation facility (17.7%). They explained that cucumber needs more water, and more water, throughout its stage of production and so that, it is being better still if farmer have irrigation facilities to help them maximize the yield potential of their crop via more irrigation facilities and more water for their grown plants.

Table 5. Constraints to cucumber production among small-scale farmers

Constraints	Frequency	Percentage
Inadequate storage facility	110	19.8
Inadequate Transportation	92	16.6
Inadequate credit facility	75	13.5
Unstable market forces	88	15.8
High cost of production input	94	16.9
Inadequate water and Irrigation facility	98	17.7
Total	555*	100

Source; field survey data 2023.
*Multiple responses.

CONCLUSION WITH RECOMMENDATIONS

Cucumber is a special nutritious vegetable crop that means many things to many people. However, an average cucumber farmer in the study area with a gross margin income of ₦ 2,680,580.00, a Net farm income of ₦2,658,080.00. and a return on investment of 3.63; is profitable in the study area. Some input resources employed which are underutilized including fertilizer, labour and land should be increased up to economic optimum level where resource use efficiency equals unity. Also, the major constraint to Cucumber production is inadequate storage facility and and inadequate irrigation facility. The farmers should form themselves into cooperatives, and develop their own social capitals and approach banks and government for loan facilities, adequate storage facilities and irrigation facilities needed to increase productivity and profitability of Cucumber production in the study area.

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PRODUCTION FUNCTION AND PROFITABILITY OF SWEETPOTATO PRODUCTION IN SABON-GARI LOCAL GOVERNMENT AREA OF KADUNA STATE, NIGERIA

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ABSTRACT
The study investigated the production function and profitability of sweetpotato production in Sabon-Gari Local Government Area of Kaduna state. An average farmer incurred a total variable cost of ₦218,000.00 per hectare and realized a total revenue of ₦375,000.00. His sweetpotato average yield was 5000kg per hectare. A gross margin of ₦157,000.00 per hectare was achieved; and this makes the enterprise a profitable one. The Cobb-douglas regression estimates indicated an R-square value of 0.75 implying an 75% variation in total farm output of sweetpotato among the sampled farms were explained by the production inputs specified in the model. The major constraint faced by an average sweetpotato farmer is inadequate storage facilities. The study recommends that farmers form themselves into cooperative in order to benefit from government facilities and credit necessary to meet their storage and other problems.

INTRODUCTION
Sweetpotato (*Ipomoea batatas* (L.) Lam) is classified as a root and tuber crops that are notably grown in the sub-Saharan Africa (SSA), owing to its adaptive nature and appreciable productivity per unit area and time. (NRCRI, 2005). Sweetpotato thrives well and produce high yields even on marginal soils. Although it was recently being grown in Nigeria as commercial crop as well (Kisiangani and Pasteur, 2008); it was commonly grown by most smallholder farmers as an insurance crop, should other crop fail to yield well. It also serves for them as a crop to rely on for their subsistent living (Low *et al.* 2007).
Sweetpotato crop means many things to different people in Nigeria. It is often consumed boiled or fried and sometimes; being processed into various confectionaries like cakes, pancakes, rolls, buns, and puff puff ; and can also be made into sweetpotato gari (Odebode, 2004). The roots and tops could be made into a dried meal and fermented silage to feed livestock like pigs, cattle and poultry. Also, its vines, leaves and roots can be processed to animal feeds to feed sheep, goat, rabbits (Tewe *et al*. 2003), Also, the crop can be processed into ethanol and biofuel at economic scale. Sweetpotato can yield 137 litres of ethanol per metric tonnes of sweetpotato tubers (Akorado, 2009).
However, the almost static food growth rate in the face of explosion in population growth rate has been the main food problem in Nigeria. This has also leads to rises in food prices over the years. Ohajianya (2014), posited that the main food problems are food supply deficits, poverty and uneven distribution of income in terms of ability to buy food. Adequate production of most Nigeria staple crops such as sweetpotato which is consumed in many parts of the country, and which can be processed into wide range of food and utility products will contribute positively to the agricultural sector. The general objective of farmers is sustainable production at reasonable levels and at minimal risk, to satisfy their subsistence and commercial needs (Beets, 2010). Although, recent research works on sweetpotato might have concentrate more on the bio experimental researches on the crop, this study is focused on production function and profitability of Sweetpotato in the study area. The specific objectives of the study are to; i. determine the input-output relationship in sweetpotato production in the study area; ii. estimate the cost and returns of sweetpotato production; and iii. examine the constraints of sweetpotato production in the study area.

METHODOLOGY
The study was conducted in Sabon-Gari Local Government Area of Kaduna state of Nigeria; located in the Northern Guinea Savannah Zone of Kaduna state. The Local Government Area is situated on a plateau of a height of about 700m above sea level of latitude 11^0 12^1 N and longitude 7^0 8^1E. The study area has two distinct seasons which are dry and wet seasons. The rainfall extends from April to October and average annually between 100 to 1000mm with a mean temperature ranging from 27.20 ^{0}C to 35 ^{0}C in the month of April. The local government area consists of 12 Districts including Samaru, Jama'a, Bassawa, Hanwa, Dogarawa, Chikagi, Muchia, Zabbi, Jushi , Angwa-gabas, Angwan-godo and Bomo; and has an estimated

population of farming families of about 246,544. Majority of the farmers grows sweetpopato, irish potato, maize, millet, groundnut, cowpea, sugarcane, rice and vegetables such as cucumber, tomato, onion, and pepper are cultivated. The major livestock kept are goats, sheep, cattle and poultry.

The study adopted a multi-stage cross-sectional sampling survey design. Firstly, a random selection of 4 district/villages from the earlier listed 12 district was carried out. Secondly, a random selection of 30 sweetpotato farmers from each of the villages, making a total of 120 sweetpotato farmers were selected and interviewed. A well-structured and pre-tested questionnaire, was administered by trained enumerators. The data collected include those of socio-economic characteristics of respondents, input and output quantities used, revenue and cost variables and major constraints to sweetpotato production in the study area was gathered.

The study employed descriptive statistics including use of frequency distribution, percentages and means to describe the socio-economic characteristics, input-output of sweetpotato production and constraints farmers faced in sweetpotato production. The profitability of sweetpotato production was estimated on per hectare basis using farm budget techniques; including the estimation of gross return, gross cost, gross margin, net return and benefit-cost ratio (undiscounted). The formulas used for the calculation of profitability include: Gross return, GR = P×Q; where, P = Selling price of the product (Naira); Q = Yield per hectare (Kg). Gross cost, GC = TFC + TVC; where TFC = Total fixed cost (Naira); and TVC = Total variable cost (Naira). Gross margin, GM = GR – TVC. Net return, NR = GR – GC; and Benefit-cost ratio = Gross benefit / Gross cost.

Also, multiple regression analysis was used to analyse the production function, and estimation of the physical and economic relationship between the input and output factors in sweetpotato production. **-** The model in its general implicit form was; $Y = F\ (X_1, X_2, X_3, X_4, X_5, e_t) \ldots\ldots\ldots Eqn\ 1$; Where, Y = output of sweetpotato (kg), X_1 = Seeds (kg), X_2 = Fertilizer used (kg), X_3 = Pesticides (l), X_4 = Labour input (man/hr) X_5 = Land (ha), e_t = error terms. Among the functional forms tried, the best fit Cobb-douglas double-log form was used; and the explicit forms of the model is; $\log Y = a + b_1 logX_1 + b_2 logX_2 + b_3 logX_3 + b_4 logX_4 + b_5 logX_5 + e_t (Double\ Log\ ) \ldots\ldots\ldots\ldots. Eqn\ 2$

RESULTS AND DISCUSSION

Table 1 shows the result of input and output resources for sweetpotato production per hectare in the study area. An average farmer who cultivated an hectare of land uses 25kg and 200kg of seedstock (planting propagules vines) and fertilizers respectively. Also, 2.0litres and 152Man-hour of pesticides and labour respectively was used. However, Table 2. Show the estimated Cobb-Douglas production function result that, except for the coefficient log of seeds, that was not significant; all other coefficients of variables log fertilizer, log pesticides, log labour and log land are positive and significant at 5%, 5%, 10% and 10% respectively. The substantial R-square value of 75% also indicated that each of the specified explanatory variables actually well explained the output of sweetpotato per hectare in the study area.

In Table 3, the results of costs and returns analysis of an average smallholder sweetpotato producers in Sabon-Gari Local Government Area of Kaduna State were as shown below. The result revealed that, the enterprise is profitable in the area, with an average gross margin of ₦157,000.00 per hectare achieved and the average total costs of production of ₦235,600.00 per hectare was incurred to achieve this feat. The rate of returns on investment which was 0.59 means that, for every naira invested, the farmer will make ₦ 0.59 profits. These findings agreed with Alabi and Ajooku (2012), and Njoku and Offor (2016).

Table 1: Description of Input and Output Resources of Sweetpotato Production per Hectare

Variable	Maximum	Minimum	Mean	Std. Deviation
Seed-stock (Kg/ha)	28.88	15.78	25.03	4.50
Fertilizer (Kg/ha)	298.34	145.31	200.14	35.30
Pesticides (L/ha)	4.12	1.23	2.01	2.51
Labour (Man-hr)	242.45	137.23	152.34	155.20
Land (Ha)	1.68	0.42	1.06	1.88
Yield (Kg)	6822.32	3243.43	5001.21	763.20

Source; field survey data 2023.

Table 2: Estimated co-efficient of Cobb-Douglas production function for sweetpotato farming

Variables	Coefficients	standard Error	t-value
Constant	320.03	314.25	1.02
Log Seed (X_1)	0.223^{NS}	0.242	0.92
Log Fertilizer (X_2)	0.151**	0.139	1.09
Log Pesticides (X_3)	0.234**	0.121	1.93
Log Labour (X_4)	0.243*	0.232	1.05
Log Land (X_5)	0.143*	0.111	1.29

Source; field survey data 2023.

*** implies significant at, 1%; ** at: 5%; * at: 10% and NS at: Not significant.

R^2 = 0.75

Adj. R^2 = 0.66

F = 35.4

Table 3: Average Costs and Returns of Sweetpotato Production per Hectare

S/n	Variables	Unit/ha (Kg/ha)	Unit price (₦/kg)	Value/ha(₦/ha)	Percentage (%)
1.	Variable Cost:				
a.	Planting Propagules (Kg/ha):	25	600	15,000.00	6.4
b.	Fertilizer (Kg/ha):	200	300	60,000.00	25.5
c.	Pesticides	2	450	9,000.00	3.8
d.	Labour Cost (Man-hr/ha):	152	750	114,000.00	48.4
e.	Transportation (₦)	-	-	20,000.00	8.5
	Total Variable Cost (TVC)			218,000.00	
f.	Fixed costs (a.)	Rent on land (₦ / ha)	15,5000	15,500.00	6.57
g.	Fixed costs (b.)	Depreciation of farm tools (₦)	2,500	2,100.00	0.9
	Total fixed cost (TFC)			17,600.00	
2.	Total cost (TC)			235,600.00	100
3.	Total Revenue:	5000	75	375,000.00	
4.	Gross Margin (GM)			157,000.00	
5.	Net farm income (NFI)			139,400.00	
6.	Return per capital (Naira) invested		(NFI/TC)	0.59	

Source; field survey, 2023.

RECOMMENDATION AND CONCLUSION

The study found that the production of sweetpotato is profitable in the study area. It also showed that variables including fertilizer, pesticides, labour, and land are important determinant of output levels achieved. And that the major constraint to production is lack of storage facility. The study recommends the formation of farmers into cooperative group and for government interventions of loans to farmers.

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MARKET DEVELOPMENT OF SELECTED AGRICULTURAL CROPS AND THEIR VALUE CHAINS IN NIGERIA

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ABSTRACT
In the agricultural marketplace, raw agricultural products and their value chains are developed through post-harvest activities, value chain processing, technology transfer and business models. Three selected agricultural crops, namely cassava, oil palm and rice were assessed in the light of these major tools for their market development. The selection of these three agricultural crops was based on their demand and versatility amongst Nigerians. Post-harvest activities entail the operations after harvesting, preventing damage; thereby increasing their shelf life. Value chain processing entails the processing of these crops from raw agricultural products to end-use consumption. Technology transfer includes technologies such as disease-resistant seed varieties, high oil-yielding seed varieties of these crops to realize optimal production after value chain processing. Business models involve the selection of private sector-led business model for accelerating the market development of harvested products of these agricultural crops. Cassava farming, oil palm farming and rice farming has been done successfully for several years in Nigeria and therefore poses no new investment risks. This paper ended by outlining sustainability concerns of these crops and recommendations towards market development of these selected agricultural crops in Nigeria.
Keywords: *Cassava, Market Development, Oil Palm, Rice, Value chain.*

INTRODUCTION
The primary and secondary processing of selected agricultural crops have a relatively high potential for use in energy supply and value chains (Thessa *et al.,* 2016). This is because in the production of primary agricultural products, relatively little energy is used. Also, in primary and secondary processing, large amounts of energy are used, and agricultural feedstocks and residues are often available at the processing location (Thessa *et al*, 2016). In tertiary processing, large amounts of energy are used but very limited feedstocks and agricultural residues are available. In some cases, primary processing is done by farmers. In these cases, this reduces the potential for using agricultural residues for energy supply. In addition, most primary and secondary processing is done in the vicinity of locations where the primary products are produced in order to avoid transportation of large volumes of primary products. These primary products are produced in rural areas with poor access to energy supply. Tertiary processing is often done in close urban areas and/or industrial areas, close to the customer base or transportation hubs, with better access to energy supply (Ladan, 2017). In Nigeria, with the availability of biomass at processing locations and existence of medium and large processing companies, the value chains of these three agricultural crops have best potentials for energy supply (GNESD, 2011). Despite geographic differences, this review discussed ways to enhance agricultural production, optimize processing activities and accelerate business models for market development of selected agricultural crops, namely cassava, oil palm and rice as well as their value chains in Nigeria.

Cassava (*Manihot esculenta*):
Food and Agricultural Organization (FAO) projected that by Year 2025, about 62% of global cassava production will come from sub-Saharan Africa (Adelekan, 2012). Cassava is an important staple crop in Nigeria and is Africa's second most important food staple in terms of calories consumed per capita and a major source of calories for roughly two out of every five Africans (Scarlett et al, 2020). Cassava is a staple of choice across cultures and social divides in Nigerian households. Much of the tuber produced from this root crop is consumed locally as traditional meals. It is the most important crop by production and the second most important by consumption (FAO, 2013). Cassava is grown in all agro-ecological zones of Nigeria but thrives better in the rainforest and derived savannah areas. Production is highest in the North Central and South-South regions of Nigeria. Nigeria is facing significant future demand for processed cassava; the cassava sector is expected to reach €7.2 billion in value by 2020. Cassava is important in Nigeria, not just as a food crop but even more so as a major

source of cash income for households. As a cash crop, cassava generates cash income for the largest number of households, in comparison with other staples, contributing positively to poverty alleviation. Cassava is usually consumed in processed forms, its processing by traditional methods is labour intensive but the applications of improved processing technology has reduced processing time and labour, thereby encouraging further production. Industrial utilization of cassava products is increasing but this accounts for less than 5% of total production (Sanni, *et al.*, 2012). For many years, the government of Nigeria is stimulating the cassava value chain, as cassava production and processing is a viable option to boost employment in the county. Measures taken to stimulate market growth in the cassava sector include institution of up to 40% of high-quality cassava flour requirements in wheat bread and 10% ethanol requirements in gasoline (of which 50% is from cassava). Cassava waste products are suitable for power generation as it contains large amount of starch; 20–35% fresh and 80.6% dry weight (Okudoh et al, 2014).

Production Chain:

Cassava is regarded as a staple food in Nigeria, as it is used to produce 'gari', 'fufu', and 'lafun'. Besides 'garri', cassava is used to produce 'Atteke', a cassava product. Cassava is used for animal feed, cassava starch, flour, ethanol, adhesives, and bread. The production chain shows the processing of cassava to "Garri" and "Atekke". The production chain shows that cassava starch is produced from cassava. From both production chains, substantial residue streams become available when processing cassava. The amount of residue becoming available in the different cassava processing steps provides an excellent basis for energy production.

Technology: To produce energy from cassava residues, several energy conversion technologies can be utilized, depending on the type of residue and energy requirements of the processor. Also, wastewater from cassava bagasse and starch residues can be used for energy production. Processing technologies and conversion processes for energy generation from cassava waste streams are impressive. Combustion and digestion can be used at relatively small scales. Cogeneration and gasification usually require somewhat larger-scale energy input for cost efficiency. Fermentation technology can be used to convert cassava into bioethanol. This technology usually uses the entire cassava and not only the residues. The selection of the most appropriate technology depends on scale of operation, availability of sufficient space for installation and energy demand of companies.

Figure 1: Processing of Cassava

Business models: Potential business models for the realization of sustainable energy supply from cassava depend on the size of the cassava processing company. Large-scale, well-equipped cassava processors can develop, build, maintain and operate power generation. These companies can bear the capital investments required to build a power system and are likely to have the knowledge and experience needed. Another option for these companies is to engage in a Design-Build-Operate-Maintain (DBOM) or a Build-Own-Operate-Transfer (BOOT) contract with third parties. With third parties, a Power Purchase Agreement (PPA) can be negotiated by cassava processors. That way, these cassava processors can receive steady energy supplies, without having to manage the plant itself. For medium- and small-scale cassava processors, it will hardly be feasible to develop and build a captive power plant internally. This can be ascribed to two facts. Firstly, the capital investments required for a captive power plant will most likely be too large for a medium- or small-scale entrepreneur in the cassava processing industry. Secondly, they usually do not have the required knowledge and skills within their firm, to develop, build, operate and maintain a waste to energy captive power plant.

Cassava Processors: Cassava is mainly cultivated in Anambra, Delta, Edo, Cross River, Imo, Oyo, Ogun, Niger, Rivers, Kwara and Benue States (Daniels *et al.,* 2011). There are about 1,200 large scale farmers (10 to1000 hectares and 5,000 medium scale farmers (6 to10 hectares in Niger Delta, supplying a handful of large processing industries and about 50 small-medium scale industries (PIND, 2011b). The National Cassava Processors and Marketers Association (NCAPMA) mentioned 65 members on their website (http://ncapma.org/directory/listing/). Large agri-food processing companies in the cassava sector have been identified in Cross River, Ogun, and Niger States.

Oil Palm (*Elaeis guineensis*):

Nigeria produced nearly 8 million tonnes of oil palm fruits (resulting in about 1 million tonnes of palm kernel) and is the third largest producer of oil palm in the world (FAO, 2009). Oil palm processing offers the empty fruit bunches, the processing waste effluent and palm kernel shells as options for energy supply. About 80% of Nigeria's palm oil production comes from scattered smallholder farmers spread over an estimated 1.6 million hectares of land. Oil Palm Plantations occupy between 200,000 and 360,000 hectares of land. Oil palm provided direct employment and income to about 5 million Nigerians (FAO, 2009). Oil palm is grown abundantly in southern Nigeria, with majority of large and small holder farms found in South-east and South-south Nigeria. The Niger Delta's nine states (Akwa Ibom, Abia, Rivers, Edo, Imo, Ondo, Bayelsa, Cross River and Delta) account for about 80% of total Nigerian palm oil production (Thessa *et al.*, 2016). But this production is dominated by the collection of palm fruits such as Fresh Fruit Bunches (FFB) from wild groves (74% of area and about 50% of supply of FFB), followed by production from private plantations (small, medium, and large farmers, 19% of area and 34% of supply of fruit) and large corporate and government owned plantations (about 7% of area, 25% supply of fruit). Other important oil palm producing states are: Ekiti, Ogun, Enugu, and Oyo. In 2012, the Government of Nigeria initiated the Agricultural Transformation Agenda for increasing palm oil production in the country (FAO, 2009). Government has distributed hybrid oil palm seedlings to farmers to replace the low-yielding and old trees; government is collaborating with farmers and private sector organizations to expand oil palm plantations. Some production increases have been recorded from this initiative. The government also supports domestic production through research.

Production Chain:

The Nigerian palm oil processing industry is made up of four identifiable channels including:

Channel 1: Traditional TPO (Technical Palm Oil)

Channel 2: Medium Technology TPO

Channel 3: Medium Technology SPO (Special Palm Oil)

Channel 4: Integrated

Channel 1 is the largest of the four channels, but it is shrinking. It is dependent on the wild grove harvest and tens of thousands of small processors, each producing between 40 and 200 litres poor quality product, produced with traditional production techniques. In this channel the end markets /end-users are food vendors, hoteliers, and households. Channel 2 is driven increasingly by improved farming techniques (commercially oriented) and by an improved processing technology for crude palm oil. The channel is comprised of the larger private producers of FFB who are integrating vertically into using more efficient processing technologies. Channel 2 is attracting the more commercially oriented actors from Channel 1 to upgrade and move into a more productive segment. It is generally expected that Channel 2 will become the dominant channel in Nigeria's oil palm value chain. This channel is already handling more than 50% of all the oil palm that is mechanically processed and commercially marketed. It has more than a thousand processors around the Niger Delta Area alone. Channel 3 represents an intermediate technology between the semi-improved processing and the expensive modern methods. Most oil palm estates produce Special Palm Oil (SPO). The channel has different actors in all the functions from input supplier, producer, processors, wholesalers, retailers, and end-users so the vertical coordination is complex. The channel is growing gradually due to high demand for the product in Nigeria. Channel 4 is comprised of the large estates with vertically integrated through processing with fully automated processing plants. Some companies like PRESCO, take the product all the way through to the fractionated Oleins and Stearins, while others sell their SPO to the secondary processors for fractionating. This channel is the model being used by the largest industries in the world from Malaysia and Indonesia, which can control the production of the fruit, the timing of its delivery to the mills, and the access to end markets. Medium and large-scale farmers in both the TPO and SPO channels seem very suitable to adapt to energy production.

Technology: To produce energy from oil palm residues, different energy conversion technologies can be utilized, depending on the type of residue and energy requirements of the oil palm processor. There are suitable processing technologies and conversion processes for energy generation from oil palm residues. The selection of the most appropriate technology depends on the scale of operation, availability of sufficient space for installation and the specific energy requirements of companies.

Business Models: Potential business models for the realization of energy production depend on the size of the oil palm processing company. Large and automated palm oil processors usually can develop, build, maintain and operate power generation. These companies can bear the capital investments required to build a power system. The most suitable business model for these oil palm processors is using the DBOM model, having third parties exploiting power plants and supplying energy to oil palm processors under PPA agreements. Both business models show a commercial potential.

Oil Palm Processors: Two companies in channel 4 are currently at the fore front in the production of SPO. These companies are PRESCO & Okomu Oil, both located in Edo State. Other actors in this channel are Golden Oil company and Envoy Oil Industries located in Anambra State, Agro Ideas International located in Akwa-Ibom State, EFB Industries Limited in Abia State and Sudit Oil in Oyo State.

Rice (*Oryza sativa L.*):

Rice production in Nigeria seems to have increased in recent years to 6.7 million tons in 2014 (Scarlett et al, 2020). Estimates indicate that over 90% of domestic rice production comes from resource poor and weakly organized small-holder farmers. Niger State produces the largest amount of rice paddies in the North Central zone at 473,000 tonnes paddy per annum (GIZ, 2015b). In the last few years, integration in the form of installation of rice mills and direct farming seems to be gaining more ground. Good examples of these are Olam and Dangote. In 2015, Olam Nigeria has invested €94 million in an integrated farm and milling facility in Nasarawa State. One of the biggest commitments for investing in rice processing was made in 2014 by Dangote Group. This Nigerian conglomerate committed to spending more than N165bn (€750 million) in rice mills, farms, and related infrastructure in a bid to supporting Nigeria's goal of becoming a net-exporter of rice (GIZ 2014). Dangote Group acquired farmland in five states, which will be used for the commercial production of rice paddy. It will also set-up two rice mills with an installed capacity of 240,000 tonnes of rice per day.

Production Chain: The Nigerian rice value chain is made up of five different channels. The integrated industrial processing mills seem the most suitable to adapt to energy production.

Processing Technology: To produce energy from rice residue, different energy conversion technologies can be utilized, depending on the energy requirements of processors. As straw is usually not available at the milling site, this residue is not a suitable feedstock for energy production at the mill location.

Business Models: For large scale rice millers, it is possible to install and manage power generation facilities internally. The large milling companies can bear the relatively high capital investments required to start energy generation using rice husk. Moreover, these companies are likely to have access to the knowledge required to build, own, maintain and operate a power plant. Another option for these companies is to appoint third parties that will be responsible for energy generation. With these third parties, a PPA can be negotiated. That way, the processors can receive steady energy supplies, without having to manage the plant itself. For medium scale rice millers, it will hardly be feasible to develop and build a power plant internally. This can be ascribed to two facts. Firstly, the capital investments required for a power plant will most likely be too large for these companies. Secondly, they usually do not have the required knowledge and skills within their firm, to develop, build, operate and maintain a waste-to-energy energy production plan. Most suitable business model for these rice millers is using a DBOM model, having third parties design, build, operate and maintain the power plant, supplying energy to rice processors under PPA agreements (GIZ, 2015). Some might prefer to use the BOOT model. For small rice millers only the DBOM model seems suitable. All business models show a commercial potential.

Rice Millers: In recent years, significant investments have been made in increasing the rice processing capacity in Nigeria. According to the Rice Millers, Importers and Distributors Association of Nigeria, the number of rice mills resulting from one plant five years ago is twenty-four at present (Simonyan and Fasina, 2013).

CONCLUSION AND RECOMMENDATIONS

The roadmap toward a future where primary production and value chain processing of these selected agricultural crops will be developed including an agricultural productive use component has been discussed. Based on this review, there are agricultural activities to prioritize and business model options that will enable better agricultural productivity. These business models include significant private sector participation to align with the private sector-led approach of the Nigerian energy sector and to reduce dependency on donor funding, ensuring long-term sustainability of these crops and their end-products. Their sustainability concerns include wastewater from effluent from their processing; indirect emissions emanating from land use changes due to crop production; water consumption; food security issues; biodiversity concerns; impact of agrochemicals on human health and ecosystems; long-term soil quality and conservation; social impacts; deforestation of natural areas. Therefore, it is important for these sustainability concerns to be taken into consideration in future for the market development of these selected agricultural crops. There is need to demonstrate returns of investment (via equipment purchases and feasibility studies) for the selection of business models to de-risk (risk factors of cultivation, storage, marketing) and attract private and foreign direct investments. These deliverables from combination of cross-sectoral engagement across the agricultural and value chain sectors alongside pilot tests is needed to drive findings and approaches identified in this review. Findings from this review showed some interesting developments and success stories in the value chain processing of these crops for socio-economic development of rural communities in developing countries like Nigeria. The recommendations of this review are:

1. Convene a working group across the agriculture and value chain sectors to coordinate, guide, and promote activities required to achieve long-term commercial viability.
2. Implement pilot tests and feasibility studies for agricultural production activities and collect operational data to refine financial models.
3. Use pilot data to design and implement recommended commercial business models and develop financial instruments for the market development of these selected agricultural crops.
4. Use lessons learned from pilot tests and feasibility studies to implement, deploy strategies, formalizing the structures needed to finance and support wide-scale policy instrument for improved agricultural production.
5. Deployment of these strategies for agricultural production activities; addressing identified barriers to agricultural development; addressing future investment risks and harnessing opportunities in the agricultural and value chain sectors with stakeholders in the industry.

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"LAFIA"

SUB-THEME 2:

Knowledge Creation and Transfer through Agricultural Research, Innovation and Extension Delivery

USE OF YAM SLIPS FOR MINI TUBER PRODUCTION

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ABSTRACT
The production of yam is beset by many problems which include weed pressure, decline in soil fertility, soil borne pests and diseases, storage pests, high labour cost of land preparation and maintenance, staking and barn making among others. The objective of this study is to generate mini tubers from yam slips to help solve the problems presented by insufficiency in yam planting materials. Five yam cultivars: TDr 89/2660, Hembakwase, Ame, Adaka, and Nwopoko were planted in the experimental site of the National Root Crops Research Institute, Umudike, in a 2 x 1 m plot size, at a planting spacing of 20cm, replicated 3times in a Randomized Complete Block Design. The seed yams were dusted with aldrex –T to prevent seed borne disease attack. Weeding was carried out at 4, 8 and 12WAP. Fertilizer NPK 15:15:15 was applied at 400kg/ha at 8WAP after the second weeding. Staking was done using trellis method of yam staking. Periodic monitoring and training of the vines was also done. Data were collected on stand count at harvest, number of seed yams, weight/plot (kg) and were subjected to ANOVA and means were compared using LSD under GenSTAT statistical software. The result showed that the available planting materials sprouted well and this may be due to the treatment with the Aldrex-T used which prevents soil borne disease attack. It also showed that the staking is a factor which promotes number of tuber and tuber size. The increase in the growth of the tuber size was also attributed to timely application of manures in form of N:P:K fertilizer and other cultural practices that was carried out timely. This study showed that, yam slips provide alternative means of generating yam mini tubers. To get good tuber size of yam, clean planting materials, timely maintenance and operations is the key.
Keywords: *Partial sectioning technique, Yam minisett, Minitubers, Yam slips*

INTRODUCTION
Yam (*Dioscorea* spp.) is generally classified under the genus *Dioscorea*, family *Dioscoreaceae*, and order *Dioscoreales*. Yams are the second most important tuber crop in the whole world after cassava, in terms of production and utilization (11TA, 2013)**.** One of the earliest attempts at partial sectioning technique was in 1975 by Nwosu (1975) at the National Root Crops Research Institute (NRCRI), Umudike, Nigeria. This method involves selecting an average sized seed yam of 300 – 400g. The proximal region including the corm was cut off to remove apical dominance. The tuber was sectioned into partially cut setts using incisions that are 1cm deep to mark out sett areas of 3 x 3cm on the tuber. In marking out each incised sett, the sectioning was first done longitudinally and then horizontally. The sectioned tuber was buried whole in a fertile compost mixture. Within few weeks, the incised part struck with vigorous roots arising from the base of the sprouting points. The sprouted sections were cut out from the tuber body and planted in the fertile field. This technique appears to double the multiplication rate from 1:5 to 1:10.
Ten years after the introduction of the partial sectioning technique for seed yam production, NRCRI, Umudike successfully developed the yam minisett technique for rapid, high volume seed yam production (Okoli *et al.*, 1982). This technology has not only increased the multiplication ratio in seed yam production to 1:30 but has reduced the cost of seed yam production. Yam minisett technology has been found to be economically viable and an easy alternative to solve the challenges presented by insufficient yam planting materials (Ironkwe *et al*., 2007). and it has been widely adopted not only in Nigeria but also across the yam belt of West Africa. In furtherance to reducing high cost of seed yams and insufficiency in availability of yam planting materials, investigations have been carried out this time, on the use of yam slips in mini tuber production. The objective of this study is to generate minitubers from yam slips to help solve the problems presented by insufficiency in yam planting materials.

MATERIALS AND METHODS
Planting materials, Design and Cultural practices:
Five yam cultivars: TDr 89/2660, *Hembakwase, Ame, Adaka*, and *Nwopoko* were planted in the experimental site of the National Root Crops Research Institute, Umudike, in a 2m x 1m plot size, at a planting spacing of 20cm, replicated 3times in a Randomized Complete Block Design. The seed yams were dusted with aldrex –T to prevent seed borne disease attack.

Weeding was carried out at 4, 8 and 12WAP. Fertilizer NPK 15:15:15 was applied at 400kg/ha at 8WAP after the second weeding. Staking was done using trellis method of yam staking. Periodic monitoring and training of the vines was also done. Which year was the experiment carried out.

Data Collection and Analysis:
Data were collected on stand count at harvest, number of seed yams, weight/plot(kg) and were subjected to ANOVA and means were compared using LSD under GenStat statistical software.

RESULTS AND DISCUSSION

Germination Rate (%):
The result on Table 1 and figure 1 showes that there was no statistically significant (P>0.05) difference among the treatment means in the germination percentage for both year 2011 and 2012. Similarly, the comparison of the varieties across the two years also showed no Significant (P>0.05) difference for percentage germination rate. However, in the year 2011 and 2012, Nwopoko and Hembamkwase gave the best promising germination rate of 22.38% and 21.72% respectively, while, *TDr 89/02660* and Ame gave the least (22.33% and 16.31% respectively) percentage of germination rate. This is an indication that the available planting materials sprouted well and this maybe due to the treatment with the Aldrex-T used which prevents soil borne disease attack. This agrees with Damudi (2013) who stated that for any planting materials to germinate and sprout well, they need to be adequately treated with recommended chemicals in which Aldex-T dust is inclusive.

Number of Seed Tuber:
The result on Table 1 and Figure 2 showed there was significant (P<0.05) difference in the number of seed tuber in year 2011 but there was no significant (P>0.05) difference in 2012. The interaction of the varieties across the two years showed no significant (P>0.05) difference. However, in the year 2011 and 2012, Nwopoko and Hembamkwase gave the best promising number of seed tuber of 28.00 and 26.00 respectively, while, *Adaka* and *Ame* gave the least (23.00 and 21.70 respectively) number of seed tuber. This is an indication that the staking is a factor which promotes number of tuber and tuber size. This is in agreement with Akoh, (2012); Manu, (2010) and Ajih, (2009), they observed that staking process assist in tuber elongation and size increase in tuberous crops.

Weight of tuber (Kg):
The result on Table 1 and Figure 3 showed there was significant (P<0.05) difference in the number of seed tuber in year 2011 but there was no significant (P>0.05) difference in 2012. The interaction of the varieties across the two years showed significant (P<0.05) difference. However, in the year 2011 and 2012, Hembamkwase gave the best promising tuber weight of 5.70Kg and 3.93Kg respectively, while, *TDr 89/*02660 and *Adaka* gave the least (3.73Kg and 2.00Kg respectively) tuber weight. The increase in the growth of the tuber size can also be attributed to timely application of manures in form of N:P:K fertilizer and other cultural practices that was carried out timely. In support of this, Adejoh, (2013); Daluba, (2010); Edibo, (2008); Ezekiel, (2006) and Olazide (2004) stated that fertile topsoils, mulches, organic manure with proper staking and weeding help to boost the tuber yield of yams most especially in tropical zones.

Table1: Stand count, number of seed yams/plot and weight of seed yam/plot on the use of yam slips for mini tuber production in 2010 cropping season

	Yield parameters					
	2011			2012		
Treatment	Stand count	Number of seed yams	Weight (kg)	Stand count	Number of seed yams	Weight (kg)
Adaka	22.67	23.00	3.80	25.7	26.00	2.00
Ame.	24.33	24.33	4.60	19.3	21.70	2.97
Hembamkwase	24.33	24.67	5.70	27.0	28.70	3.93
Nwopoko.	27.00	28.00	4.23	22.0	22.70	3.57
TDr 89/02660	22.33	24.67	3.73	24.3	24.00	2.83
Means	24.13	24.93	4.41	23.7	24.60	3.06
LSD(0.05)	5.67^{ns}	4.79*	1.67*	7.82^{ns}	8.60^{ns}	2.64^{ns}

* means significant at P<0.05, ns means not significant.

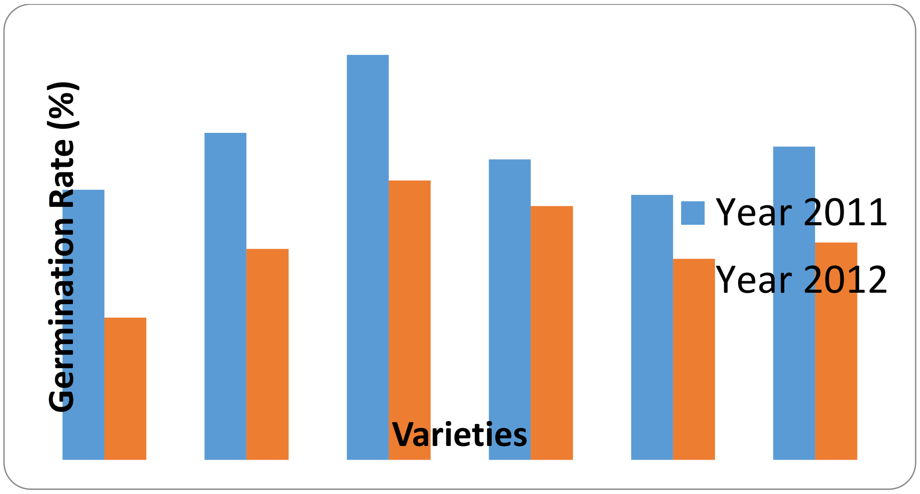

Figure 1 Germination rate (%) of the varieties across 2011 and 2012

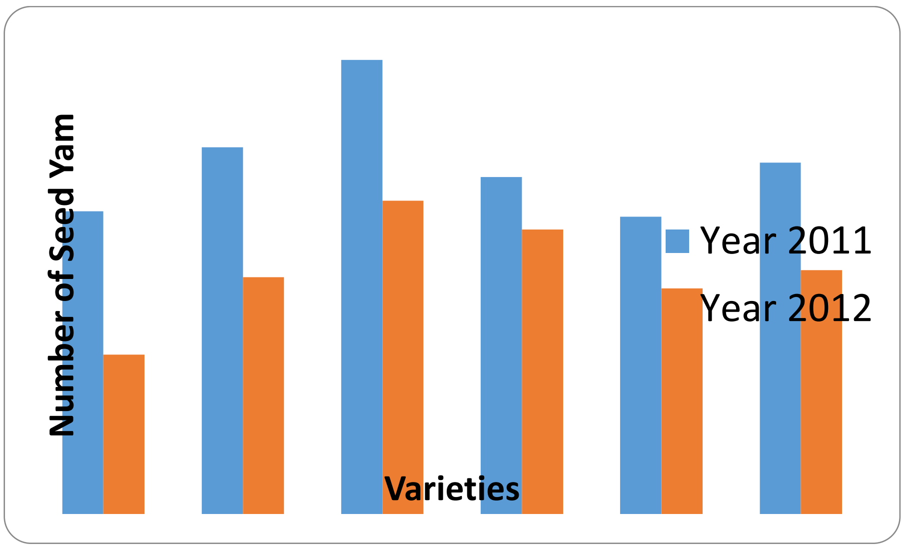

Figure 2 Number of seed tuber of the varieties across 2011 and 2012

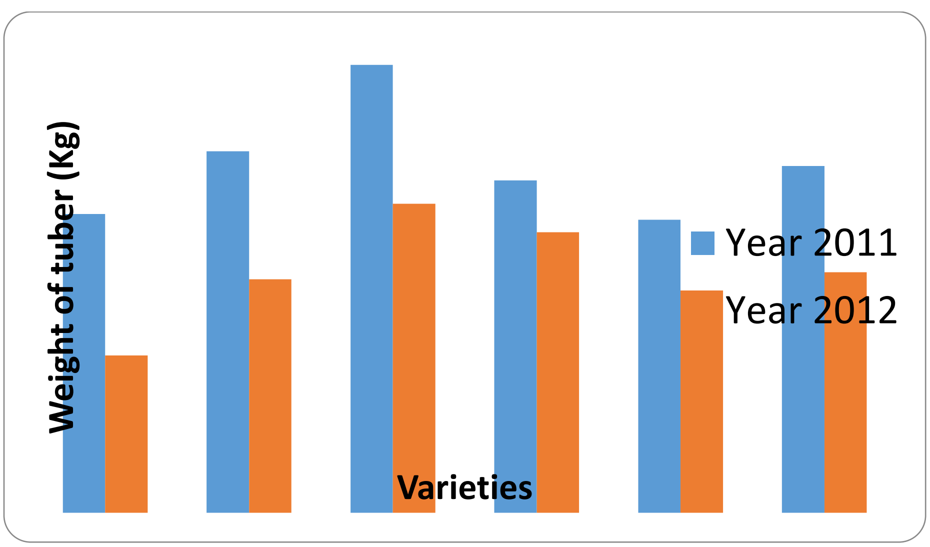

Figure 3 Weight of tuber (Kg) of the varieties across 2011 and 2012

CONCLUSION

Many problems beset yam production in Nigeria, ranging from weed pressure, decline in soil fertility, soil borne pests and diseases, leaf and shoot diseases, storage pests, high labor cost for land preparation and maintenance, staking, harvesting, barn construction and tuber quality deterioration. The contributions of the National Root Crops Research Institute, Umudike to yam improvement is highly commendable. However, the tasks before it and collaborating crop research institutes, and crop breeders are the development of alternative planting materials which do not compete with human food, non-stake yam varieties, weed tolerant, pest and disease resistant and highly adaptable yam genotypes/varieties for Nigerian farmers. The need for the adoption of molecular techniques in addition to the conventional breeding techniques cannot be over emphasized. This trial showed that, yam slips provides alternative means of generating yam mini tubers. To get good tuber size of yam, clean planting materials, timely maintenance and operations is the key.

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FACTORS INFLUENCING PARTICIPATION IN CONTRACT FARMING AMONG TOMATO FARMERS IN ANKPA LOCAL GOVERNMENT AREA OF KOGI STATE

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ABSTRACT
Factors influencing participation in contract farming among tomato farmers in Ankpa Local Government Area of Kogi State were assessed in this study. Multistage sampling technique was employed for selecting sample of 150 respondents. Primary data was used for the study. Data were collected using a structured questionnaire. Probit model and Likert Scale were used to analyse data collected. The results showed that Sex (0.008) was statistically significant at 1% alpha level, while marital status (0.049), co-operative membership (0.019) and extension services (0.034) were statistically significant at 5% alpha level in influencing participation in contract farming. Inadequate credits with the mean score ($\bar{X}$=1.61), pest and diseases attack ($\bar{X}$=1.71), high cost of labour ($\bar{X}$=1.47), poor transportation network ($\bar{X}$=1.66), long distance from the farm to the market ($\bar{X}$=1.74), inadequate co-operative societies ($\bar{X}$=1.66), high cost of agrochemicals ($\bar{X}$=1.34), irregular extension visits by extension agents ($\bar{X}$=1.34), prevalence of adulterated agrochemicals ($\bar{X}$=1.10), lack of irrigation ($\bar{X}$=1.30), and untimely supply of inputs by contracting firm ($\bar{X}$=1.32) were the serious constraints faced by tomato farmers in the study area. Contracting individuals/firms should ensure timely delivery of inputs to farmers to ensure effective operations and timely delivery of produce, extension agents should pay more visits to tomato farmers since increased frequency of visit by extension workers was found to increase participation in contract farming. Also, necessary measures should be taken by the government against the circulation of adulterated agrochemicals among farmers in the rural areas of Nigeria.
Keywords: *Contract, farming, Participation, Analysis, Factors, Influencing, Tomato, Farmers*

INTRODUCTION
Contract Farming is an agreement between farmers, processing and/or marketing firms to produce and supply specified crop(s) under forward agreements mostly at pre-determined prices (Will, 2013). Tomato farming generates profits for the farmers and thus improve their living standards, create job opportunities in agriculture and agro-allied sectors thereby boosting the overall economy of Nigeria. This provides stimulus for agricultural innovation, increasing capital for agricultural investment which could result in the development of rural economies. Buyers of the specified crop(s) may provide embedded services such as upfront delivery of inputs, pre-financing of input, delivery on credit and other non-financial services (such as extension service, provision of training for farmers, transport and logistics). Tomato farming generates profits for the farmers and thus improve their living standards, create job opportunities in agriculture and agro-allied sectors thereby boosting the overall economy of Nigeria (Nwigwe *et al.*, 2020). Small scale farmers in the rural areas of Nigeria suffer from marketing risks associated with the sale of their produce, price volatility which sometimes discourage farmers from production and poor market linkages. These have increased poverty level as well as food insecurity among rural farmers especially in the study area. Hence, this study was designed to assess factors influencing participation in contract farming among tomato farmers in Ankpa Local Government Area, Kogi State. The following are salient research questions: (i) what factors influence the participation in contract farming among farmers in the study area? and (ii) What are the constraints faced by tomato contract farmers in the study area? The objectives of this study were to:

(i) analyze the factors influencing participation in tomato contract farming in the study area
(ii) describe the constraints faced by contract tomato farmers in the study area.

Hypothesis:
H_0: socio-economic characteristics of farmers do not influence participation in contract farming
H_1: socio-economic characteristics of farmers influence participation in contract farming

METHODOLOGY
This research was conducted in Ankpa Local Government Area, located on the A233 high way in the Eastern part of Kogi State. It is found between latitude 70 15" North and 70 37" North of the Equator and longitude 70 30" East and 70 and 37"

East of the Meridian (NPC, 2006). It has an estimated population of three hundred and nine thousand, nine hundred and thirty (309, 930) people and a land mass of two hundred and sixty-two (262) square kilometre (NPC, 2006). Crops grown are Tomato, Okra, Yam, Maize, Cassava, Cowpea, Citrus, Oil Palm, Mango, and Cashew. Major livestock are goats and poultry which are reared extensively. Multistage sampling technique was used to select 150 respondents for the study. In the first stage, the three (3) major districts namely; Ankpa, Enjema and Ojoku districts were purposively selected. The second stage involved random selection of two (2) communities from Ankpa district, two (2) communities from Ojoku district and four (4) communities from Enjema district based on the prevalence of tomato farmers in those areas. The third stage involved the use of proportional sampling technique to select 10% of the respondents from the sampling frame, as shown in Table 1 below. Primary data were used for the study. Data were collected using a structured questionnaire.

Table 1: Distribution of Tomato Farmers in the Study Area

Districts	Communities	Sampling Frame	Sample Size (10%)
Ankpa	Ikanekpo	85	8
	Ogodo	40	4
Enjema	Inye	800	80
	Ofugo	107	10
	Agbeneba	90	9
	Enelie	300	30
Ojoku	Ochunobi	31	3
	Ojoku	60	6
Total		**1,513**	**150**

Source: Field Survey, 2022

Analytical Techniques

Probit Regression was used to analyse objective (i) while objective (ii) was analysed using three point Likert scale.

Probit Regression Model

Probit Regression Model was adopted for the analysis of factors influencing participation in contract farming because the dependent variable (Participation in contract farming) was a binary variable. This was adopted following Ebuenyi *et al* (2020), who applied the Probit Regression Model to assess agricultural credit Sources and accessibility in Nigeria

The implicit form of Probit model is as follows:

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}, X_{11}) \quad (1)$$

Where:

Y = Participation in contract farming (a Binary variable; 1, for participation in contract farming and 0, for non-participation in contract farming)

X_1-X_{11} = Vector of explanatory variables (predictors)

The model is specified explicitly as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \mathcal{E}_i \quad (2)$$

Where:

Y=Dependent variable (Participation in contract farming) which is a binary response variable predicted by the model (with responses coded as Yes=1, No=0)

β_1-β_{11}=Coefficients of the explanatory variables

β_0=Constant

X_1=Age of farmer (years)

X_2=Sex of farmer (Male=1, Female=0)

X_3=Marital Status (Single=1, Married=2, Divorced=3, Widow=4, Widower=5)

X_4=Educational Level (No formal education=1, primary education=2, secondary education=3 and tertiary education=4)

X_5=Household size (Number of persons)

X_6=Farming experience (Years)

X_7=Co-operative membership (Yes=1, No=0)

X_8=Farm size (hectares)

X_9=Annual income (₦)

X_{10}=Access to agricultural credit

X_{11}=Access to extension service

$\mathcal{E}_i$=Error term.

The constraints to tomato farmers were assessed using Mean scores of responses obtained from three point Likert scale:

Serious=1

Undecided=2

Not Serious=3

Mean score of each item was determined using the formula:

$$\bar{X} = \frac{\Sigma FX}{N} \quad (3)$$

Where:
$\bar{X}$ = Mean of responses
$\sum$= Sigma (Summation)
F=Frequency
X=Numerical value of the scale point
N=Number of respondents.
The numerical value of the scale points and their respective real limits are as follows:
Serious constraints = 1-1.70
Undecided = 1.80-2.49
Not serious constraints = 2.5-3.00
This means that any mean score between 1 to 1.70 depicted 'Serious constraints'
Mean score from 1.8 to 2.49 was considered as 'Undecided' while Mean score of 2.50 to 3.00 was considered 'Not serious constraints'.

RESULTS AND DISCUSSION

Factors Influencing Participation in Contract Farming among Tomato Farmers in the Study Area

The results of Probit Regression estimate on factors that influence tomato farmers' participation in contract farming in the study area is presented in Table 2. Participation in contract farming was the dependent variable while the independent variables were age, sex, marital status, level of education, household size, farming experience, membership of co-operative societies, farm size, extension services, annual income and access to credit. The result showed that the value, Prob > chi^2 (0.0348) is significant at 5% alpha level. This implies that the null hypothesis that the socio-economic variables do not influence participation in contract farming is rejected. It further implies that the independent variables in the model were jointly statistically significant in influencing farmers' participation in contract farming. Sex of the respondents which was significant at 1%, marital status (5%) co-operative membership (5%) and access to extension services (5%) were the principal determinants of participation in contract farming among tomato farmers in the study area.

The coefficient of sex is negative and significant at 1% alpha level. This implies that sex of the farmers negatively influence the participation in contract farming. This implies that male farmers are more involved in tomatoes contract farming than female farmers in the study area. This was even evidenced by the fact that majority of farmers in the study area were male. This tallies with the a priori expectation that there will be more males in tomato contract farming than females.

The coefficient of marital status was negative and significant at 5% in influencing farmers' participation in contract farming. This means that marriage negatively influences farmers' participation in tomatoes contract farming in the study area. It implies that married farmers were less likely to participate in contract farming than single farmers. This could be because married farmers have larger households and as such, higher responsibilities than unmarried farmers. This could make delivery of the crop difficult. That is, married farmers may easily breach the contract compared to unmarried ones. This is similar to the findings of Ahamefule *et al.* (2018) who reported that married smallholder farmers are 66.32% less likely to be able to repay their loans than single small holder farmers.

Membership of co-operative societies has a positive coefficient and was significant at 5%. This implies that a unit increase in the number of co-operative societies to which a farmer belongs, will lead to an increase in the probability of farmers participating in contract farming. This is perhaps because co-operative society is a medium through which contracting individuals or firms negotiate with potential contract farmers. Such co-operative societies also facilitate timely and effective dissemination of information among members. This result is similar to findings of Assogba *et al.* (2017), who reported that belonging to farmers' cooperatives associations was found to increase the likelihood of farmers' access to formal and semi-formal credit.

The coefficient of extension services was positive and significant at 5% level of significance. This means that the frequency of contacts with extension agents positively influences the participation in contract farming. This implies that if the village extension workers increase their frequency of visits to farmers' farms, the probability of participation in contract farming will be higher. It also implies deploying more extension agents to the rural areas will positively affect the probability of involvement in contract farming. This implies that extension agents educate farmers on the benefits of participating in contract farming. This is similar to Ahamefule *et al.* (2018) who reported that the number of supervisory visits is positively related to small holder farmers' ability to repay their loans and that increasing the number of supervisory visits will increases the probability of a farmer been able to repay his/her loan.

Table 2: Probit Estimate on Factors Influencing Participation in Contract Farming

Participation in CF	Coeff.	Std. error	z	p >(z)
Age	.2960595	.2753922	1.08	0.282
Sex	-1.379698	.5161482	-2.67	0.008***
Marital status	-1.039109	.5268029	-1.97	0.049**
Education	-.0411718	.2517544	-0.16	0.870
Household size	.704186	.4605727	1.53	0.126
Farming Experience	.2566738	.3377158	0.76	0.447
Co-operatives	1.377048	.5878665	2.34	0.019**
Farm size	-.1172429	.3136182	-0.37	0.709
Extension services	1.356149	.6411742	2.12	0.034**
Annual income	.2222541	.2571965	0.86	0.388
Access to credits	.6223789	.7769785	0.80	0.423
_cons	-3.229346	1.94784	-1.66	0.097
LR $chi^2(9)$	20.87			
Prob > chi^2	0.0348			
Log likelihood	-26.332234			
Pseudo R^2	0.2838			

Source: Field Survey, 2022

Note: *** means coefficient significant at 1%
**means coefficient significant at 5%

Constraints Faced by Contract Tomato Farmers in the Study Area

The result of the analysis on constraints faced by contract tomato farmers in the study area is shown in Table 3. The result shows that inadequate credits with mean score ($\bar{X}$=1.61), pest and diseases attack ($\bar{X}$=1.71), high cost of labour ($\bar{X}$=1.47), poor transportation network ($\bar{X}$=1.66), long distance from the farm to the market ($\bar{X}$=1.74), inadequate co-operative societies ($\bar{X}$=1.66), high cost of agrochemicals ($\bar{X}$=1.34), irregular extension visits by extension agents ($\bar{X}$=1.34), prevalence of adulterated agrochemicals ($\bar{X}$=1.10), inadequate flow of information ($\bar{X}$=1.67), lack of irrigation ($\bar{X}$=1.30), and untimely supply of inputs by contracting firm ($\bar{X}$=1.32), were the serious challenges faced by tomato farmers in the study area. But farmers were not decisive about theft ($\bar{X}$=1.91) being a constraint or otherwise. Inadequate market information ($\bar{X}$=2.50) was not a serious constraint to the tomato farmers in the study area. This findings is consistent with Enemosa *et al.* (2022) who reported that inadequate credits, shortage of funds, Lack of technical knowledge, Knowledge and skills limitation and High cost of post-harvest materials were severe constraints to post-harvest management training needs for tomatoes farmers in Niger state, Nigeria. Enemosa *et al.* (2022) also reported that inadequate market information and theft of produce were not severe constraints to post-harvest management training needs for tomatoes farmers in Niger state, Nigeria.

Table 3: Estimate of Constraints Faced by Tomatoes Contract Farmers

Constraints	Serious	Undecided	Not serious	Mean	Decision
Inadequate credit facilities	*83(69.2)*	*0(0.00)*	37(30.8)	1.61	Serious
Inadequate market information	*30(25.0)*	*0(0.00)*	90(75.0)	2.50	Undecided
pest and diseases attack	74(61.7)	*6(5.00)*	40(33.3)	1.71	Serious
High cost of labour	91(75.8)	*0(0.00)*	29(24.2)	1.47	Serious
Poor transportation network	77(64.2)	*5(4.20)*	38(31.6)	1.66	Serious
Long distance from the farm to the market	52(43.3)	*46(38.3)*	22(18.3)	1.74	Serious
Inadequate co-operative societies	80(66.7)	*0(0.00)*	40(33.3)	1.66	Serious
High cost of agrochemicals	99(82.5)	*0(0.00)*	21(17.5)	1.34	Serious
Irregular extension visits by extension agents	91(75.8)	*15(12.5)*	14(11.7)	1.34	Serious
Prevalence of adulterated agrochemicals	107(89.2)	*13(10.8)*	7(9.30)	1.10	Serious
Inadequate information flow	79(68.5)	*0(0.00)*	41(34.2)	1.67	Serious
Lack of irrigation	100(83.3)	*2(1.70)*	18(15.0)	1.30	Serious
Untimely supply of inputs by contracting firm	99(82.5)	*2(1.70)*	19(15.8)	1.32	Serious
Theft	60(50.7)	*5(6.00)*	10(41.7)	1.91	Undecided

Source: Field Survey, 2022

CONCLUSION

In conclusion, sex, marital status, membership of co-operative society and extension services were the principal factors that influence/determine participation in contract farming among tomato farmers in the study area. Inadequate credit facilities, pest and diseases attack, high cost of labour, poor transportation network, long distance from the farm to market, inadequate co-operative societies, high cost of agrochemicals, irregular extension visits by extension agents, prevalence of adulterated agrochemicals, inadequate information flow, lack of access to irrigation, untimely supply of inputs by contracting firm were the serious constraints to contract tomato farmers in Ankpa Local Government Area of Kogi State.

RECOMMENDATIONS

Based on the findings of this study, the following policy recommendations were made:

(i) Contracting individuals/firms should ensure timely delivery of input to the farmers to ensure effective operations timely delivery of produce.

(ii) Necessary measures should be taken by the government against the circulation of adulterated agrochemicals among rural farmers.

(iii) Extension agents should be charged to intensify their activities and as such pay more visits to tomato farmers since increased frequency of visit by extension workers was found to increase participation in contract farming

(iv) Since membership of co-operative society increases participation in contract farming, formation of more co-operative societies by the farmers is highly imperative.

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ASSESSMENT OF THE EFFICACY OF NURU SMARTPHONE APPLICATION IN IDENTIFICATION AND MANAGEMENT OF CASSAVA VIRAL DISEASES IN KEBBI STATE, NIGERIA

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ABSTRACT

Information and communication technology (ICT) has helped in developing tools that are capable of identifying crop diseases and pests damage, but faces a greater challenge due to the variability of symptoms. However, several novel techniques for diseases and pests identification that use image recognition systems have been developed. This study was conducted to assess the efficacy of NURU smartphone application in identification and management of cassava viral diseases. PlantvillageNURU is an application that can be used in an android phone to detect and diagnose viral diseases on cassava. Data from 100 respondents were collected using amulti-stage sampling technique and analyzed using descriptive statistics. The findings revealed that most (92.0%) of the respondents reported that they would be inclined to confirm cassava virus when plants have stunted leaves or yellow leaves. With regards to management of the cassava diseases, most (51.0%) of the farmers mostly practiced removal of infected stems. But the introduction of NURU application was perceived to play a vital role in determining and monitoring diseases from cassava farm with a mean of 4.41 ($\bar{X}$ = 4.41), and WAVE Participatory surveillance effectively managed the viral diseases affecting cassava thereby increasing cassava yield with a mean of 4.47 ($\bar{X}$= 4.47). However, the capability of NURU application as a tool to detect cassava diseases and pests was excellent. The implication of this study is that, NURU can be an effective tool for in-field diagnosis of cassava diseases and has the potential to be a quick and cost-effective means of disseminating knowledge to farmers, particularly on the identification of disease symptoms and their management practices. Hence, the need for creation of more awareness on the use of NURU in cassava diseases diagnosis is necessary.

Keywords: *Identification, NURU Application, Cassava, Diseases, Management*

INTRODUCTION

Cassava has a wide range of pests and diseases that constrain its production, but the two virus diseases, Cassava mosaic disease (CMD) and Cassava brown streak disease (CBSD) are the most economically damaging in Africa. Nigeria is the leading producer of cassava in the world (Ezedinma *el al.,* 2007). The production of cassava is concentrated in the hands of numerous smallholder farmers located primarily in the south and central regions of Nigeria. According to (FAO. 2003), about 50% of cassava harvested is wasted due to production and postharvest inefficiencies at the farm level. The rest is consumed as food in a few, limited ways as its production is not commercially oriented to serve the needs of industry. However, successive virus disease pandemics have resulted in losses worth hundreds of millions of dollars each year, threatening the livelihoods of all those who depend on this source of calories. To this end, participatory surveillance in collaboration with Plant Village of Pennsylvania State University (USA) was commenced through regular cassava disease diagnostics based on the use of an intelligent application called NURU. This application is used in other parts of Africa and Asia but not frequently used in Nigeria. Currently Plant Village is a public good resource built at Pennsylvania State University for diagnosis of viral diseases. These include the viral diseases of cassava (CMD and CBSD) and the damage caused by CGM.

Statement of the Research Problem

Cassava products are increasingly becoming popular in Nigerian food and agricultural markets. Cassava production is currently threatened by cassava mosaic disease (CMD) and cassava brown streak disease (CBSD) both largely propagated through the exchange of infected planting materials among farmers, and resulting in losses of over 1 billion USD annually (Legg *el al.,* 2015). Awareness raising and training of cuttings multipliers and cassava producers in the use of healthy planting material is the best alternative for disease leaching and can lead to significant production improvements. To this end, Participatory surveillance in collaboration with Plant Village of Pennsylvania State University (USA) through regular cassava disease diagnostics based on the use of a smartphone application called NURU. The application is used in other parts of Africa and Asia but not frequently and adequately used in Nigeria. NURU is a deep learning object detection model for diagnosing plant diseases and pests developed as a public good by Plant Village (Penn State University). In addition to providing instant pest/disease diagnosis, the application hopes to provide guidance on control, and helps farmer to source healthy planting material of improved varieties by linking users to the International Institute of Tropical Agriculture IITA Seed Tracker application.

METHODOLOGY

The study area was Kebbi State, Nigeria. Multi-stage sampling technique was used in this study to select actors who are in cassava production. Primary data were used for this study and they were collected by means of structured questionnaire. The analytical tools that were used include descriptive statistics (frequency, percentage, mean, standard deviation and ranking)

RESULTS AND DISCUSSION

Traditional Approach in Identifying Cassava Viruses

Most (92%) of the respondents reported that they would be inclined to confirm cassava virus when plants show stunted leaves or yellow leaves (8%) (Table 1). This shows that farmers have prior knowledge of cassava diseases. With regards to management of the disease, farmers mostly practiced removal of infected stems (51.0%). Other farmers (32%) used insecticide to control insect vectors, while a small fraction (4%) of the respondents used clean planting material. These results indicate that the respondents in the survey area lacked adequate knowledge on management aspects. Providing the farmers with extension services only does not always lead to increased land productivity since many farmers still do not have sufficient technical knowledge and they faced shortage of farm labour (CUTS, 2011).

Table 1. Traditional Approaches Used in Identifying Cassava Virus Diseaes

Variable	Frequency	Percentage
Traditional ways used to confirm cassava virus		
Leaves stunted	92	92
Yellowish leaves	8	8
Total	**100**	**100**
Management		
Removing infected plant	51	51
Use of insecticide to control	32	32
Crop rotation	2	2
Use of clean planting material	4	4
No action	11	11
Total	**100**	**100**

Source: Field Survey, 2022

Perception of Farmers in Identifying Cassava Diseases Using NURU Application

The result presented in Table 2 shows that after rating the perception of respondents in identifying cassava diseases using NURU application. All the perceptions agreed with the following statements, potentiality of the application to improve yield of cassava production ($\overline{X}$ = 4.54), Using NURU is better than traditional diagnosis ($\overline{X}$ = 4.54), Using NURU application tool can monitor and manage cassava farm from diseases ($\overline{X}$ = 4.54), the new application could be used to diagnose disease on cassava farm ($\overline{X}$ = 4.47), usefulness of the application ($\overline{X}$ = 4.46), the capability of NURU to determine cassava pests and diseases symptoms in cassava production ($\overline{X}$ = 4.44) and impact of the application to determine disease ($\overline{X}$ = 4.41) as well as the rate capability of the application is the best ($\overline{X}$ = 4.41). These results indicate that NURU has potentials to be applied to a wide range of disease and pest problems that affect farmers and also the application will improve planting material to enhance their output. In addition, the application is capable of diagnosing cassava diseases in cassava production in order to improve their family livelihoods. These findings confirm the findings of Souter *et al.* (2005) and Sife *et al.* (2010), who both asserted the potential of mobile phones application in reducing vulnerability.

Table 2: Perception of Farmers in Identifying Cassava Viruses Using NURU

	Statements	Mean	SD	Remark
1	Potentiality of the NURU application	4.54	0.67	Agreed
2	The use of NURU is better than traditional diagnosis	4.54	0.65	Agreed
3	NURU tool can monitor and manage cassava farm from diseases	4.54	0.65	Agreed
4	The New application could be used to diagnose disease on your cassava farm	4.47	0.64	Agreed

5	Useful of the application	4.46	0.65	Agreed
6	capability of the application	4.44	0.63	Agreed
7	Impact of the application to determine disease	4.41	0.63	Agreed
8	The rate capability of the application is the best	4.41	0.67	Agreed

Source: Field Survey, 2022

CONCLUSION AND RECOMMENDATION

It was concluded that farmers confirmed cassava diseases only when the plants become stunted or show yellow leaves and mostly managed cassava diseases by removing infected stems or use of insecticide to the control vectors. NURU application can be an effective tool for in-field diagnosis of cassava diseases, particularly on the identification of disease symptoms and their management practices. Therefore, it was recommended that creation of more awareness on the use of NURU is necessary in cassava diseases diagnosis.Farmers should be encouraged to use NURU application to control and manage CMD and CBSD in their field.

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ARABLE CROP FARMERS INFORMATION NEEDS ON THE USE OF SOAP OPERA FOR AGRICULTURAL ENTERPRISE IN OYO STATE, NIGERIA

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ABSTRACT

The study examined Arable crop farmers' information needs in using soap opera for sourcing Agricultural Information in Oyo State, Nigeria. Using a multistage sampling procedure, 120 farmers were randomly selected across the study area. Data were collected with the use of interview schedule on farmers' enterprise characteristics, information needs and perceived constraints to the use of soap opera for sourcing agricultural information. Data were analyzed using descriptive (means and percentages) and inferential (Chi-square) statistics at p=0.05. All the respondents (100%) were involved in crop production. Crop produced by farmers varied from cereals (40%), Tuber crops (26.7%), vegetables (20.8%) and legumes (12.5%). Higher proportion (95.3%) of farmers would like the soap opera to cover crop planting procedure (29.2%), future market price (42.5%), marketing strategies (30.8%) and daily rainfall prediction (40.0%), land and boundary dispute (53.33%), ethnic dispute resolutions (46.67%). Unstable power supply (52.5%), unfavourable broadcasting hour (50.0%) and irrelevant information (48.3%) were identified as constraints to the use of soap operas for agricultural enterprise promotion. It is recommended that soap opera for agricultural enterprise promotion should focus on crop with emphasis on preferred agricultural information types.

Keywords: *Soap Opera, Agricultural Information, Arable Crop farmers*

INTRODUCTION

Information in agricultural development is very critical because, it serves as a tool for communication between stakeholders and also a channel for assessing trends and shaping of decisions (Darshan *et al*., 2017). Farming requires timely and technical information hence, the need for extension services. However, due to some factors extension services are not readily available to farmers. A consensus exists that extension services, if functioning effectively will lead to improve agricultural productivity hence, providing farmers with necessary information that will help them optimize their limited resources (Muyanga and Jayne, 2006). The basic information needs of farmers are information on crops, production techniques, production equipment and agricultural inputs, market information, and weather forecast among others (Milovanović, 2014). Soap opera, sometimes called "soap" for short, is an ongoing episodic work of dramatic fiction presented in a serial format on Television or radio. The name soap opera stems from the original dramatic serial broadcast on radio that had soap manufacturers such as Procter & Gamble, Colgate-Palmolive and Lever Brothers as sponsors and producers. Soap opera forms an integral part of modern mass media messages and it follows that, sources on mass media are valuable. It is a branch under Entertainment Education being a strategy for development communication that shares behavior change premises with other development communication theories and strategies (Buenting and Brown, 2013; Brown and Singhal, 1993). It is trans-cultural and encapsulates a universal appeal that fascinates members of most culture in which it incorporates both imagery and dialogue, this is because soap opera is a combination of the visual image and linguistic (Marx, 2007). Soap opera on television as a medium of disseminating information can be fully utilized to channel new technologies and innovations related to agriculture to farmers that will further increase their productivity.

Problem Statement

The power of entertainment in shaping the perceptions and practices of viewers and listeners cannot be overemphasized. Both the radio and television Entertainment-Education (EE), shows programs, movies, and music that do not only command attention of their audiences, but also reinforce their existing positive behaviors by demonstrating new behavior that affect audience emotions (Coleman 1986; Olajide and Yahaya 2003). The importance of information in every society cannot be overemphasized. The agriculture sector in developing countries is becoming increasingly knowledge intensive and researchers at the global, regional, and national levels continue to generate new information but due to various factors, extension services are not readily available to all farmers. However, not all institutions have fully embraced social media as a tool for disseminating information or sharing research outputs.

However, little evidence exists on the information needs of farmers in the use of soap opera utilization for sourcing timely agricultural information useful for promotion and development. It is against this background the study tends to achieve the following objectives.

The broad objective of the study is to assess arable crop farmers' information needs in using soap opera for sourcing agricultural information

The specific objectives include:

- described socioeconomic characteristics of the respondents
- identify farmers' sources of information
- ascertain enterprise information that arable crop farmers uses soap opera to address
- identify the constraints in the use of soap opera by arable crop farmers

METHODOLOGY

Multi stage sampling procedure was used to select respondents for this study. The first stage involved purposive selection of 2 Local Government Areas from each senatorial district of the state with the highest number of registered farmers. The second stage involved random sampling of 50% of the registered farmers from the selected LGAs, and the third stage involved selection of 10% of the registered farmers were randomly selected to give a total of 120 farmers used for the study. Frequency counts, means and percentages were used to examine the various data of respondents.

RESULTS AND DISCUSSION

Table 1 show that majority (94.17%) of the respondents were males while 5.83% of them were females. This implies that male farmers were more involved in farming than females in the study area. The result supported the findings of Edeoghon *et al*., (2008) which says that males were more involved in arable cropping than females in Edo State. The result shows that age range of 31 to 59 years were the majority with 55.83%, followed by those above 60 years with 35.83%, and 8.33% were less than 30 years respectively. This implied that most of the people were active people who can still practice arable crop production. Also findings in the Table showed that majority (99.17%) were married while (0.83%) are singles. The result agreed with the findings of Onasanya (2007) who reported that most crop farmers in Ogun State are married; and Soyebo *et al.* (2005) stated that agriculture is very much practiced by married people to make ends meet and cater for their children. Furthermore, many of the respondents (54.16%) were Muslims, followed by Christians 45.01% while the remaining 0.83% practiced traditional religion.

The table further shows that many of the respondents (42.5%) has a household size of less than 6 persons, 36.7% had a household size of between 6-10 members, and 20.8% had above 10 household size respectively.. Also the table further revealed that 16.6 % of the respondents had no formal education, 46.7% had primary education, 25.8% had secondary education and 10.9 % had other educational qualifications respectively. Finally, the result shows that majority (62.5%) had 6-10 years' experience, 30% had farming experience of 1 to 5 years, while 7.5% had above 10 years of farming experience respectively

Table 1: Socioeconomic characteristics of the respondents

Variables	Frequency	Percentage	Mean
Sex			
Male	113	94.17	
Female	7	5.83	
Age			
≤30	10	8.33	
31- 59	67	55.83	
>60	43	35.83	
Marital status			
Single	1	0.83	
Married	119	99.17	
Family size			
1-6	51	42.5	
7-10	44	36.7	
Above 10	26	20.8	
Educational level			
No formal	20	16.6	
Primary school	56	46.7	

Secondary school	31	25.8
Others	13	10.9
Farming experience		
1-5	36	30
6-10	75	62.5
Above 10	9	7.5
Primary occupation		
Farming	120	100.0

Source: Field survey, 2018

Table 2 shows that 37.5 % of the respondents got information through the radio, 8.4% of the respondents in the study area got information from extension agent, 33.3% got information from Farmer's Association, and 20.8% received information from television. This is in line with Churi *et al*. (2012) who stated that majority of the farmers mentioned radio broadcast as their sources of agricultural information.

Table 2: Sources of agricultural Information (n=120)

Sources of information	Frequency	Percentage
Radio	45	37.5
Extension agent	10	8.4
Farmers association	40	33.3
Television	25	20.8

Field survey: 2018

Table 3 shows that 40.0% of the respondents produced maize only, 26.7% produced cassava only, 20.8% produced (maize and cassava, and 12.5% produced other arable crops respectively. This is in agreement with the findings of Olajide (2017), which stated that most of the farmers are involved in more than one type of crop (mixed Cropping) in other to diversify their means of livelihood. Results in Table 4 show that 29.2% of the farmers' crop based information were on crop planting procedures, 25.8% on fertilizer application, 20% on pest and disease management, 11.7% were on harvesting techniques, and 13.3% on storage facilities respectively. The Table revealed that 42.5% of the respondents sought information on the future market prices of their products, 30.8% sought information on marketing strategies while 26.7% sought information on the current prevailing market prices of their products. Furthermore, the table revealed that 40.0% sought information on daily weather forecast, 33.3% on seasonal rainfall pattern and 26.7% on drought prediction respectively. Finally, 53.33% sought information on land and boundary dispute while 46.67% on ethnic dispute resolution.

Table 3: Crops produced by the respondents (n=120)

Type of Crops	Frequency	Percentage
Maize only	48	40.0
Cassava only	32	26.7
Maize and cassava	25	20.8
other arable crops	15	12.5
Total	120	100

Field survey: 2018

Table 4: Distribution of Farmers Based on their information Needs (n=120)

Information items	**Frequency**	**Percentage**
Crop based information		
Crop planting procedure	35	29.2
Fertilizer application techniques	31	25.8
Pest and diseases management techniques	24	20.0
Harvesting techniques	14	11.7
Storage techniques	16	13.3
Marketing based information		

Current market price	32	26.7
Future market price	51	42.5
Marketing strategies	37	30.8
Climatic information		
Daily weather forecast	48	40.0
Seasonal rainfall prediction	32	26.7
Drought prediction	40	33.3
Legal Information		
Land and boundary dispute	64	53.33
Ethnic dispute resolution	56	46.67

Source: Field survey, 2018

Determining the perceived constraints of using soap opera for sourcing agricultural information dissemination

Table 5 shows the perceived constraints associated with the use of soap opera for sourcing agricultural information in the study area. The result shows that 52.5% of the respondents identified unstable power supply as a severe constraint, 50.0% identified unfavorable broadcasting hours as a severe constraint, 48.3% of the respondent sees irrelevant information as a severe constraint, while 60.0% and 42.5% sees inability to comprehend soap opera message and language barrier as mild constraints, respectively.

Table 5: Distribution of respondents based on perceived constraints of soap opera (n=120)

Constraints	Severe constraints	Mild constraints	Not at constraints
Language barrier	32 (26.7)	51 (42.5)	37 (30.8)
Unstable power supply	63 (52.5)	45 (37.8)	12 (10.0)
Uninteresting story line	32 (26.7)	48 (40.0)	40 (33.3)
Unfavorable broadcasting hours	60 (50.0)	45 (37.5)	15 (12.5)
Irrelevant information	58 (48.3)	34 (28.3)	28 (23.3)
Untimely agricultural information	46(38.3)	39(32.5)	35(29.2)
Inability to comprehend soap opera message	21 (17.5)	72 (60.0)	27 (22.5)

Source: Field survey, 2018 * Multiple responses

CONCLUSION

Farmers' information need in soap opera utilisation for agricultural enterprise promotion include crop planting procedure, future market price, marketing strategies, daily weather forecast, land and boundary dispute, and ethnic dispute resolutions. The use of soap opera for enterprise promotion may be constrained by unstable power supply, unfavorable broadcasting hours and irrelevant information.

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DETERMINANT OF FOOD INSECURITY AMONG FARMERS IN ENUGU STATE, NIGERIA

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ABSTRACT
The study was conducted in Enugu State using 120 respondents. Primary data were obtained using questionnaire and oral interview. Percentage, frequency, mean and logistic model analysis were used to analyze the data. The result of the logistic regression model shows that the coefficients of educational level (0.764364) and access to extension services (0.43241) were positive and significant. Furthermore, the constraints to attainment of food security were high cost of labour, poor access to land and credit. The need to enhance the farmers' access to credit facility, labour saving devices and extension services were recommended.

Keywords: *Determinant, Food insecurity, Farmers, Enugu State, Nigeria.*

INTRODUCTION
In sub-Saharan Africa countries, the roles of agriculture in economic growth and development are well documented in recent literatures (FAO, 2004; Graaff *et al*., 2011).) However, the gain does not significantly manifest on the people and the economy due to numerous constraints in agricultural production, with resultant miserable crops yield and food insecurity (Ibrahim *et al*., 2009, Delvaux and Paloma, 2018). The consequences of food insecurity, particularly the chronic type within certain populations according to FAO (2004) perpetuates socioeconomic inequalities and limits the potential for social and economic advancement within the societies. However, Food security is built on four main dimensions – food availability, accessibility, utilization and stability. In this sense, people are food secure only when there is stability of food availability, accessibility and proper utilization over time (Kaine and Ume, 2017).

In Nigeria, successive governments have embarked on numerous policies and programmes which included Agricultural Development Programmes (ADPs), Operation Feed the Nation (OFN), and so on among others, in order to boost farmers' farm productivity for enhanced food security. Yet food insecurity, hunger and poverty continued to multiply at alarming rate in the country (Abu and Soom, 2017). The farmers whose income and livelihood depend on agriculture were worse-off (Babatunde *et al*., 2007). This study is geared towards investigating food insecurity of the farmers in relation to their socioeconomic characteristics for policy formulation and implementation. Specifically, the objectives are to: (i) describe the socioeconomic characteristics of the farmers, (ii) determine the effect of farmers 'socioeconomic characteristics on their food insecurity and (iii)identify constraints to attainments of food security in the study area

MATERIALS AND METHODS
Enugu State lies between latitudes 6°30'N and 7°10'N of Equator and longitudes 6°35' E and 7°30' E of Greenwich Meridian. The state has an estimated population of about 4.1671 million people (NPC, 2006) and land area of 16,727 square kilometers (km^{2}). The inhabitants were mainly agrarians and still engage in non-agricultural activities. A well-structured questionnaire was used to collect data for the study. Random sampling technique was used to select one hundred twenty farmers who were respondents for the study.

Method of Data Analysis

The objectives of the study were achieved using simple descriptive statistics such as percentage, frequency and Logit Regression Model.

Model Specification

Logit regression model:

The logit regression model was used to examine the determinants of food insecurity of the farmers. The model, as given by Kaine and Ume, (2017) is expressed thus:

$$P_r(Y = 1/X_i) = in\left(\frac{Y}{1-Y}\right) = a + b_1X_1 + \dots \dots \dots \dots + b_7X_7 + U \quad \text{…………………..(1)}$$

Where: Y is Food security status of the ith farmer (food secure = 1, food insecure = 0),
P (Y = 1/*X*) is the Probability of Y (attaining r *I* food security) occurring, given that X has occurred, *a* is constant intercept, b1 - b7 are coefficients of the independent variables to be estimated and X - X are explanatory variables defined as follows: is X_1 = age (years), X_2 = Level of education (years*)*, X_3= Membership of Organization(member =1, otherwise = 0), X_4 = Access to extension services (access = 1 and otherwise = 0) and *U* is error term.

RESULTS AND DISCUSSION

Table 1 indicates that 31.67% of the respondents were between 20 to 40 years, while 68.33% were 41 years and above .This infers that most respondents were youthful and *they were* expected to have a positive effect on labour supply which should in turn contribute to increase in farm productivity and food security (Ogbonna and Ume, 2022). Also, majority (70.83%) of the respondents attained various forms of formal education, while 29.17% had no formal education. Education attainment enhances individual's resource prudency and risk averse in adopting improved technologies to boost their food security through high outputs (Abu and Soom, 2016). Moreover, 83.33 % of the populations studied were members of different cooperative organizations, while only 18.67% were not. Cooperative according to Babatunde *et al.* (2007) aids in improving her members' farm productivity for enhanced odds of being food secure through training and credit access. Table 1 showed that only 33.3% of the respondents had contacts with extension agents, while the majority (66.7%) had no contact. This indicated that extension outreach was poor; which implies poor access to improved technologies for high productivity, leading to high propensity to be food insecure (Delvaux and Paloma, 2018).

Table I: Distribution of Respondent According to Socioeconomic Characteristics

Variables	Freq.	Percentage
Age		
20 – 40	38	31.67
41 and above	82	68.33
Level of Education		
No formal education	35	29.17
Primary school	60	50
Secondary school	20	16.67
Tertiary	5	4.16
Organization(Dummy		
Yes	20	16.7
No	100	83.3
Extension Services		
Yes	40	33.3
No	80	66.7

Sources: Field survey, 2022.

The Logit regression model was used to identify factors that determine cooperative members' access to loan. . The age of the farmers' coefficient was negatively signed, indicating that aged farmers were more food insecure than youthful ones. The aged farmers are usually not strong enough to tackle farming that is usually tedious and energy sapping. Also, the educational level of the farmer was positively signed, indicating that farmers that acquired formal education are more food secured than their counterpart. Literatures show that educated people are more receptive to innovations for high farm outputs (Kaine and Ume, 2017). Further, the coefficient of access to extension services was positively signed, connoting that farmers with access to extension services have high farm outputs. This may probably be due to access to improved technologies and provision of technical assistants by the change agents compare to farmers without access (Ibrahim *et al.*, 2009). Most (31.50%) of the respondents had poor access to credit and hence poor food security. The poor access to credit could be related to high interest rate as charged by lending agencies (Babatunde; *et al;* 2007). The least (14.65%) had poor access to extension services (Table 3). This could be related to wide ratio of farmers to extension officers (Ogbonna and Ume, 2022).

Table 2 The Logit regression results

Variable	Coefficient	**Standard Error**	t-value	P>|t|
Age of the farmer	- 0.0252305	0.009675	- 2.61*	0.130
Educational level	0.764364	0.234136	3.26***	1.215
Extension services	0.43241	0.13673	3.16***	0.004
Organization	0.32870	0.46721	0.70354	0.007
Constant	8.097321	2.009821	4.03***	0.021

Sigma	1.387748 ***	0.292630

Source: Field Survey, 2022

Table 3 Limiting Factors to Attainment of Food Security

Variable	Frequency*	Percent
Poor access to credit	86	31.50
P00r access to land	75	27.47
High cost of labour	72	26.38
Access to Extension services	40	14.65
Total	273	100.00

*Multiple Responses

Source: Field survey 2022

CONCLUSION AND RECOMMENDATIONS

The food insecurity of the farmers was positively and significantly influenced by educational level and access to extension services. The factor limiting food security were access to credit, land and high cost of labour.

Based on the results, the following recommendations were made:

(i)There is need to enhance farmers access to educational programmes such as adult education, seminars and workshop in order to boost their production and productivity.

(ii) Extension agents should be motivated to be responsive to their duties through payment of enhanced salaries and other fringe benefits on time.

(iii)There is need to develop labour saving devices such as hand driven ploughs and distribute them to farmers by government agencies concerned and even Non –governmental Organization(NGO).

(iv)The land use act of 1976 should be revisited, thus making land available to genuine farmers to cultivate.

(v) There is need to enhance farmers' access to credit through commercial banks at reduced interest rate.

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EFFECTS OF ADOPTION OF IMPROVED RICE VARIETIES ON RICE FARMERS' LIVELIHOOD STATUS IN KWARA STATE OF NIGERIA

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ABSTRACT
This study analyzed the effects of adoption of improved rice varieties on rice farmers' livelihood in Kwara State of Nigeria. Three-stage sampling technique was used to select one hundred and nine (109) rice producers in the study area. Structured questionnaire complimented with interview scheduled were used for data collection. Data collected were analyzed with the aid of descriptive statistics (frequency, percentages and mean) and inferential statistic (Tobit Regression Model). Finding showed that FARO 57 (75.2%) and FARO 54 (74.3%) were the dominantly adopted varieties of rice. The coefficient of number of improved varieties (0.0590437), farm size (0.0412416) and farming experience (0.0031312) statistically ($p<0.05$) influenced increase in the livelihood of rice farmers. The major constraints to the adoption of improved rice varieties were poor road network (83.5%) and poor output (79.8%). It was recommended that feeder roads should be constructed by State and Local Government authorities in order to ease the movement of farmers' produce from farms to points of processing. Furthermore, farmers should be sensitized on how to boost their output for better livelihood status. Lastly, more lands should be committed for rice production.

Keywords: *Adoption, Improved, Rice varieties, Farmers' Livelihood status*

INTRODUCTION
Rice (*Oryza sativa*) is one of the most cultivated crops in the world. It is the third most important cereal grown and consumed globally after wheat and maize (Agro-Nigeria, 2018). In Nigeria, rice is cultivated in almost all ecological belts of the country as they all provide favourable environment to support the crop's cultivation (Agro-Nigeria, 2018). Rice is the staple food for many African countries and constitutes a major part of the diet for many others. During the past three decades, the demand for rice has increased steadily, playing a major role in the strategic food security planning policies of many countries in sub-Saharan Africa (WARDA, 2011). Evidently, development, food security and livelihood status cannot be achieved without rapid agricultural growth, hence assisting the rural poor to enhance their livelihoods and food security in a sustainable manner is a great challenge. Many improved rice varieties exist that can be grown in Nigeria. For instance, the National Cereal Research Institute (NCRI), Baddegi had released many improved rice varieties that are suitable for cultivation in different agro-climatic conditions. The varieties were classified into four main groups namely; early maturing varieties (FARO 27 and FARO 44), medium maturing varieties (FARO 29, FARO 35, FARO 37, FARO 50, FARO 51, FARO 52 and FARO 57), and the late maturing varieties (FARO 7, FARO 8, FARO 12, FARO 14 and FARO 15 and deep water (floating) areas, FARO 7, FARO 14 and FARO 15, respectively (NCRI, 2009). FARO 44 is one of the many developed rice varieties that is widely distributed and highly adopted compared to other developed varieties (Adesina, 2012). It is, therefore, necessary to determine the effect of adoption of improved rice varieties on farmers' livelihood status in Kwara State. The objectives of the study are to identity the improved rice varieties adopted and determine the effects of their adoption on farmers' livelihood status.

RESEARCH METHODOLOGY

This research took place in Kwara State. The State, which is located in the North Central Nigeria, lies between latitudes 8º-10ºN and longitude 2º45'-6º4'E of the Greenwich meridian. It covers an estimated land area of about 36,825 square kilometers or 8% of the total area of Nigeria. According to National Population Census (NPC) (2006), the state has a population of 2,591,555 peoples, spread across the sixteen Local Government Areas, which was projected to be 3,005,409 as at 2017 using an annual population growth rate of 2.5% (World Bank, 2013). The major food crops produced in the state are mostly cereal crops namely rice, maize, sorghum, millet, cow pea, melon and they constitute the main staple food, aside root and tuber crops (Ajadi *et al.*, 2011). Multistage sampling technique was employed in this study to select the sample size. This involved four stages of selection. The first stage involved random selection of two Local Government Areas (LGAs) in the State. In the second stage, three (3) villages were randomly selected from each LGA, making a total of six (6) villages. In the fourth stage, a proportional sampling was used to select 10% of the respondents from the sampling frame to give a total sample size of one hundred and nine (109) farmers. Primary data were used for this study. Data were collected by the researcher, assisted by trained enumerators, using structured questionnaire and complimented with interview schedule. Descriptive statistics such as mean and frequency distribution was used to analyse objective (i). Effects of adoption of improved rice varieties on rice farmers' livelihood objective (ii) was achieved using Tobit regression model. The implicit and explicit forms are specified as follows:

$$Y = \alpha + X_i \beta + \varepsilon_i \quad (1)$$

$$Y = a + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 \ldots \beta_n X_n \quad (2)$$

Y=livelihood status index (LSI)

X_1 = number of improved varieties adopted, X_2= farm size (ha), X_3= farming Experience (years)
X_4 = number of training, X_5 = annual income (₦), X_6= cooperative membership (number), X_7= Credit (amount received), X_8= Access to extension (number), X_9 = fertilized used (kg), X_{10} = Agrochemical used (litre), X_{11} = Simpson index (Amount).

RESULTS AND DISCUSSION

Improved Varieties adopted by the Respondents

Table 1 showed that majority (75.2%) of the rice farmers adopted FARO 57. This may not be unconnected with high yielding and early maturity experienced with FARO 54. Also, 74.3% of rice farmers adopted FARO 54. Furthermore, 71.5% of the rice farmers adopted FARO 44. This might be owing to some favourable qualities exhibited by FARO 44 such as high yield, early maturity, and high resistance to pest and diseases and market acceptability. This finding agreed with Tsado *et al.* (2018), who reported that majority of the rice farmers in Niger State adopted FARO44 improved rice. The least adopted improved rice variety in the study area was FARO 62. This might be due to the relatively newness of the variety, which made the farmers to shy away from it; it could also be due to lack of familiarity, as farmers were yet to find it compatible with their existing practices or lack of awareness of it.

Table 1: Distribution of respondents according to improve varieties adopted (n=109)

Variables*	Frequency	Percentage
FARO 44	78	71.5
FARO 54	81	74.3
FARO 57	82	75.2
FARO 60	76	69.7
FARO 62	68	62.4

Sources: Field survey, (2019); Multiple responses

Effects of Adoption of Improved rice Varieties on Farmers' Livelihood Status

The result of regression analysis in Table 2 showed the effects of adoption of improved rice varieties on farmers' livelihood in the study area. The result showed that the Pseudo R^2 value was 0.9626, implying that about 96.3% of the variations that occur in improved rice varieties were explained by the independent variables included in the model, while the remaining 24.3% were due to external factors not captured by the researcher. The coefficient of number of improved varieties (0.0590437) was significant at 1% level of probability. This signifies that more access to improve rice varieties tend to increase outcome and income of farmers and have positive effect on their livelihood. The coefficient of farm size (0.0412416) was positively significant at 5% level of probability. This signifies that increase in size of farm land will lead to increase in the livelihood of improved rice adopters. This finding agreed with Afodu *et al.* (2020) who reported that increase in farm size reduces food insecurity among rice farmers in Ogun State, Nigeria. The coefficient of farming experience was negatively significant at 5% level of probability, implying that as farmers experience increases, there is tendency for the livelihood to be affected.

Table 2: Effects of adoption of improved rice varieties on farmers livelihood (n=109)

Variables	Coefficient	Z-value
Number of improved rice varieties	0.0590437	4.68***
Farm size	0.0412416	2.18**
Experience	0.0031312	2.30**
Access to training	0.0449753	1.31

Annual income	1.99e-07	1.83
Cooperative membership	-0.0131772	-0.89
Access to credit	-0.0265287	-0.87
Extension	0.0030054	0.20
Quantity of fertilizer	-0.0160687	-0.60
Quantity of agrochemical	0.0008348	1.21
Simpson index	3.28e-06	1.65
Constant	0.4063803	4.03***
Pseudo R^2	0.9626	
Chi square	47.18***	
Log likelihood	48.09992	

Sources: Field survey 2019

*** Significant at 1% level of probability, **=Significant at 5% level of probability, *=Significant at 10% level of probability

Constraint Facing Adoption of Improved Rice Varieties

The result in Table 3 revealed that poor road network (83.5%) was the major constraint facing the adoption of improved rice varieties in the study area. Lack of good road is obvious and peculiar to most of the rural areas where rice is been produced. Another constraint was poor output (79.8%), implying that rice farmers, despite adopting improved rice varieties could not get the desired output. This agreed with Mohammed *et al*. (2019), who reported that inadequate output and inadequate improved varieties were among the challenges to adoption of Faro (39) Rice Project Technology by farmers' in Agricultural Zone 1 of Niger State, Nigeria. The problem associated with land is common among farmers in North Central due to the activities of Fulani herdsmen and other forms of land encroachment that reduce farmers' access to adequate farmland for farming activities. This agreed with Zalkuwi (2019), who reported that land tenure problem is one of the challenges to rice production in Nigeria. Also, incentive like agrochemicals and fertilizers could not be accessed by rice farmers due to the non-availability or that the available inputs were mostly hijacked by political heads and distributed by those loyal to them.

Table 3: Constraints facing adoption of improved rice varieties

Variables	Frequency	Percentage	Rank
Poor road network	91	83.5	1st
Poor output	87	79.8	2nd
Land tenure system	72	66.1	3rd
Labour and youth migration	66	60.6	4th
Processing problem	65	59.6	5th
Seasonal attack of pest and diseases	61	55.9	6th
Inadequate improved varieties	34	31.2	7th

Sources: Field survey 2019

CONCLUSION AND RECOMMENDATIONS

Based on this finding, it can be concluded that majority of rice farmers adopted FARO 57, FARO 54 and FARO 44. The coefficient of number of improved rice varieties, farm size, and farming experience had effect on the adoption of improved rice varieties on farmers' livelihood status. The major constraints to the adoption of improved rice varieties were poor road network, poor output and land tenure system. It was recommended that feeder roads should be constructed by State and Local Government authorities in order to ease the movement of farmers' produce from farms to the point of processing. Also, farmers should be sensitized on how to boost their output for better livelihood status. Lastly, more lands should be committed to rice production.

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IMPACT OF COVID-19 ON CASSAVA FARMERS OUTPUT IN LAFIA LOCAL GOVERNMENT AREA, NASARAWA STATE, NIGERIA

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ABSTRACT.

This study assessed the impact of Covid-19 on the farm output among Cassava farmers in Lafia Local Government Area. The specific objectives were to describe the socio-economic characteristics of the cassava farmers, estimate the costs and returns in cassava production, analyze the impact of Covid-19 farm output among cassava farmers and identify the constraints faced by cassava farmers in the study area. The data for this research work were obtained through primary source by the used of structured questionnaire, to elicit useful information from the practicing cassava farmers interviewed schedules was used as well. The data were collected with the used of multistage random sampling technique. The result revealed that cassava farmers were in their active year, also cassava production was a profitable enterprise in the study area. Results in Table 3 further revealed that 31% of variation of farm output among cassava farmers were caused by the explanatory variables included in the multiple regression model. While 69% was not explained by the explanatory variables. The F-value was 2.45 and significant at 5% probability level, this implies that there is significant relationship between Covid-19 and selected explanatory variables. Results further revealed that cassava farmers faced multiple constraints. Based on the findings of this study, it is concluded that Cassava farmers were in their active years, considering the age percentage of 70% for the range between 18 -55years in the study area, The study also indicated that Cassava production was a profitable enterprise, there is relationship between Covid-19 and farm output in cassava production and cassava farmers also faced some production constraints in the study area. It is recommended that there is need to encourage practicing and prospective entrants into the business by making production resources available and accessible to the practicing farmers. This will enhance production, reduce widespread poverty, create job opportunity and better the lives of the citizenry. There is need for Government and Non-Governmental Organizations (NGOs) to coordinate more research into latest varieties of cassava, production techniques and Covd-19 to serve as extension packages since extension contact was found to affect the farm output of cassava farmers. Government and community leaders should try and establish more markets for cassava commodities for farmers to sell their products to avoid glut.

Keywords: *Impact of Covid-19, Cassava Farmers, output.*

INTRODUCTION

Cassava is a very important crop to the economy of Nigeria. It is estimated that about 30 million farmers grow cassava with average yields of about 11 metric tons per hectare and annual output exceeding 33.8 million metric tons. Estimate of output in 2011 was over 52 million metric tons (FAO, 2013). Apart from being a source of food to about 200 million people in the sub-Saharan Africa, cassava can contribute to employment creation, income generating capacity and food security for many households in Nigeria (Ogunleye and Ojedokun, 2014). An Italian who works in Nigeria flew into Lagos from Milan on 25th February 2020 and had contact with a Nigerian from Ogun state, and on 27th February 2020, he was diagnosed with covid-19. This was announced as the index case being the first recorded case of Covid- 19 in the country (Bernard, 2020). The news came not as a surprise because earlier before that date a legislative member at the national Assembly in Abuja raise alarm over the absence of security personnel at the various international airports in Nigeria whose responsibility ordinarily should be to conduct a routine check of every passenger on arrival. Following this development there was the enforcement of a 2-week lockdown on 30th March 2020 for three very busy commercial region of the country, namely Ogun State. Lagos state, and the Federal capital Abuja following the advice offered to the Nigerian president by the National centre for disease control {Bernard, 2020].

The lockdown of these three states was followed by other state in Nigeria in order to forestall the chances of contracting and spreading the deadly virus. These was the prohibition of interstate travel and general restrictions on the movement of goods and services with the exception of essential services (Been and Aziz, 2020), Scholars have researched on Covid-l 9 pointing it devastating impact of the disease on the economy as well as the health-care delivery system. As it is, Nigeria is divided into six geopolitical zones, namely, north- east, north- west, north- central, south- west, south- south, and south- east. The Igbo ethnic nationality, our primary focus in this study, occupies the south east with states such as Imo, Anambra, Abia, Enugu, and Ebonyi State. There are other Igbo- speaking groups in Rivers, Delta, and Edo state, respectively, in south- south Nigeria.

The Igbo of south eastern Nigeria has no access to the sea and thus landlocked with all their coastal neighbors in Calabar or Bonny having no linguistic sameness. This was the circumstance that made it possible for the federal military government to enforce the food blockade policy against Biafra that yielded defeat for secessionist in 1970. The federal government greatest weapon amidst machine guns was hunger. The same inability of the region to cultivate sufficient food for it populace is still much of a challenges to the collective survival of the population. The southeast region currently suffers from a food deficit in terms of producing crops such as onions, tomatoes, yam, potatoes, carrot, oranges, and other crops. The major source of protein such as cows, goats and the aforementioned crops is supplied from the northern region of Nigeria. The various established cases of clashes in Igbo land between farmers and herders stem from the wanton destruction of crops by cattle among other causes.

The covid-19 outbreak with all it challenges is indeed a clarion call and pointer to the reality of food insecurity in Igbo land creating an imperative for immediate response. In spite of the federal government directive that vehicles and lorries carrying food, water, and other essential services should be allowed free movement , the corrupt nature of the security agents such as the police, army, civil defense corps, federal road safety corps, and neighborhood watch securities at the various security posts on the federal highways made this impossible. After extorting so much from Lorries carrying food, the prices of commodities skyrocketed and the population suffered for their overdependence on food coming from the northern region of Nigeria. The population claims of the food supply in the form of palliatives to the region from the federal and state governments were only heard on radio and television, respectively, while the voting population languished into total lack.

The importance of food cannot be overemphasized. It is an essential ingredient needed by all living beings for survival, and it availability determines the standard of living of the people at all times (Iwuagwu, 2008). The environment and geography of people determine what food they eat and it availability at all times within this context is the issue of climate and it suitability to agriculture. This is closely linked to soil fertility evidenced in land context made possible by rainfall. In essence, there is an evident nexus between agriculture and the physical environment of Igboland (Uzozie, 1979). Igboland is peopled by subsistence farmers with emotional ties to the attributes of their land notably "soil type, climate and vegetation" (Iwuagwa, 2008). The aim of this study is to analyze the impact of Covid-19 on farm output among cassava farmers in the study area. The specific objectives are to: describe the socio-economic characteristics of cassava farmers in the study area, estimate the costs and returns among cassava farmers in the study area, analyze the effect of Covid-19 on the farm output among cassava farmers in the study area and identify the constraints faced by cassava farmers in the study area.

METHODOLOGY

This study was conducted in Lafia Local Government Area of Nasarawa State. Lafia is located within Longitude 08°32 East of Greenwich Meridian and Latitude 08°33 north of the Equator. It has a land area of 2,73755sqm and altitude of 181 .53 (570tf) and shares boundaries with Obi Local Government Area to the South , Nasarawa-Eggon local Government Area to the North, Doma Local government area to the west, and Quanpan local government area in Plateau State to the East (Nasarawa State, 2006). Lafia Local Government Area has a distinct wet season which commences in March and ends in October, and dry Season Starts from November and ends in February. The average annual rainfall is approximately 151.9mm and temperature is high throughout the year with an annual maximum mean range of 34.3 Celsius and annual minimum mean range of 22.8 Celsius (Nasarawa State, 2006).

Lafia Local Government Area is made up of eight (8) Districts among which are: Lafia east, Lafia West, Kayarda, Agyaragun Tofa, Akunza, Awuma, Agyaragu and Ashangwa. The soil texture is sandy loam and very fertile for crops like sorghum, cowpea, cassava, rice, yam, groundnut among other are cultivated in the area. There are tree crops such as cashew, mango, palm tree, oranges that are grown in the area. Other economic activities carried out in the .Lafia local government Area are: trading, hawking, food vendors, artisans, transporters etc. Based on the 2001 population census, the estimated figure was 215,145 people. The major tribes found in the local government are: Eggon, Kanuri, Migili, Gwandara, Hausa/Fulani, Alago, Mada, Igbo, Yoruba and others. A Multistage sampling techniques was used, the first stage involved selection of 5 districts out of twelve districts. The second involved random selection of two villages each from the five districts to give a total of ten (10) villages. Third stage was random selection of 2 households from each of the 10 villages to give the total of twenty (20) as the sample size of the study. Primary data for the study was collected from the respondents using structured questionnaire and oral interview. The questionnaire contained questions covering all the objective of the study such as socio-economic characteristics, costs and returns, impacts of Covid 19 on farmers' outputs and constraints faced by the respondents. The following analytical techniques were used, frequency distribution tables, percentage, arithmetic mean, variance and standard deviation was used to achieved objectives i and IV

Budgeting Techniques: Gross Margin Analysis: This is the difference between the Gross Farm Income (GFI) and the Total Variable Cost (TVC).

GM = GFI – TVC

Where GM = Gross Margin, GFI = Gross Farm Income, TVC = Total Variable Cost.

(b) Net Farm Income: It is the difference between the Gross Margin (GM) and Total Fixed Costs (TFC).

NFI = GM – TFC

Where NFI = Net Farm Income, TFC = Total Fixed Cost and GM is as previously defined. This tool was used to achieve objective ii of the study.

In order to achieve objective III which is to analyze the effect of Covid-19 on the cassava farmers output multiple linear regression model was used. The implicitly functional form is specified as: $Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7)$…….. ei

Where

Y = Cassava yield (dependent variable)

X_1 = Covid-19 impact

X_2 = Educational level (years spent in school)

X_3 = Access to credit (Dummy variable, 1 for yes, 0 otherwise)

X_4 = Extension visit (Number of times)

X_5 = Input price (₦)

X_6 = Transportation cost (₦)

X_7 = Medication (₦)

e_i = Error term

RESULTS AND DISCUSSION

The socio-economic characteristics of respondents such as age, sex, marital status, educational level, farming experience, household size, land acquisition, source of labour, farm size, membership of cooperative ad extension contact were analyzed using simple descriptive statistics are presented in table 4.1. Age refers to the number of years person has lived and it is determinant factor of the quality labour supply in farming enterprise. The result presented in table 1 revealed that most (75.0%) of the respondents were within the age bracket of 18-55 years. This is an indication that a large proportion of the farmers in the study area were in their productive years. Production was dominated by male (80.0%) farmers. The females (20.0%) are usually single parent. Generally, female members of households usually engage in domestic responsibilities as well. Most (85.0%) of the respondents were married. Married couples contribute significantly to the general progress of farm enterprises and where wives are given separate portions of land to produce crops, increase in output can be substantial. Educational attainment levels of the farmers was relatively high as 79.5% of them had one form of education or the other. It will be easier for educated farmers to adopt the latest extension packages in the study area. Result presented in table 1 showed that 95.0% of the respondents had household size between land 10, 19.0% accounted for 11-20 while 1.0% and 21.30 0.0% of the farmers had household sizes respectively. Result in table 1 further reveals that a largest proportion of the respondents (40.0%) had years of farming experience of between 1.10, 30.0% accounted for 11-20, 40.0% while 21.30, 25.0% of the farmer had farming experience of 31-40, 5.0% respectively. The various methods of land acquisition by the respondents are also presented in table 1. Inheritance (40.0%) and rented (40.0%) has topped the list, while the least method was through purchase (20.0%) in the study area. The result in table 4.1 revealed that most 80.0% of the respondents engaged in source of labour family labour has 20.0% while hired labour has 80.0%. Result in table 4.1 further revealed that a large proportion of the respondents (95.0%) had farm size of between 1-10 hectares

Table 1: Distribution of respondents according to socio-economic characteristics

Variables	Frequency	Percentage
Age		
18-30	4	20.2
31-40	6	30.0
41-50	7	35.0
51-60	2	10.0
61 above	1	5.0
Total	**20**	**100**
Gender		
Male	16	80.0
Female	4	20.0
Total	**20**	**100**
Marital status		
Married	17	85.0
Single	3	15.0
Total	**20**	**100**
Educational level		
Primary	3	15.0
Secondary	5	25.0
Tertiary	10	50.0
None of the above	2	10.0
Total	**20**	**100**
Household size		
1-10	19.0	95.0

11-20	1	5.0
21-30	-	-
Total	**20**	**100**
Farming experience		
1-10	6	30.0
11-20	8	40.0
21-30	5	25.0
31-40	1	5.0
Total	**20**	**100**
Land acquisition		
Inheritance	8	40.0
Purchased	4	20.0
Rented	8	40.0
Total	**20**	**100**
Source of labour		
Family labour	4	20.0
Hired labour	16	80.0
Total	**20**	**100**
Farm size		
1-10	19	95.0
11-20	1	5.0
Total	**20**	**100**

Source: Field Survey Data, 2023

The profitability assessment of cassava production in the study area was done using Gross Margin (GM) analysis. The estimated costs and returns of cassava farmers are presented in Table 4.2. The total variable cost in cassava production was ₦195,712.33 per hectare, comprising of 20.4% of labour cost, 10.6% cassava cuttings, 6.5% of herbicides cost, 16.8% of fertilizer cost and transportation cost accounted for 44.5%. The fixed costs of cassava production per hectare was ₦2,491.31, comprising of 0.3% of hoes while 0.5% accounted for axes and cutlass each respectively. The total cost of production for a typical cassava farmers was ₦198,203.64 per hectare. It is clear from the analysis that cassava production needs large capital in order to increase the profitability level of the cassava farmers as well as increasing the living standard of the farmers in the study area. The average gross returns obtained by cassava farmers was ₦372,425.34 per hectare. The net farm income was ₦177,221.75 per hectare. The return per naira invested was ₦1.89. This implies that cassava production was profitable in the study area. Therefore, there is need for cassava farmers to expand their production scope so that they can obtained more returns in order to better their living standard in the study area. This study agrees with the findings of Okoye *et al.* (2010) that the production of cassava was profitable in South-Eastern Nigeria.

Table 2: Average Costs and Returns per Hectare of Cassava Production in the Study Area

Costs and Returns	Amount (₦)	% of total cost
(A) Variables Cost		
Labour	40,463.85	20.4
Cassava cutting	21,024.62	10.6
Herbicides	12,773.85	6.5
Fertilizer	33,304.62	16.8
Transportation	88,145.39	44.5
Total variables	195,712.33	98.7
(B) Fxied Costs		
Hoes	560.23	0.3
Axes	914.46	0.5
Cutlass	1,016.62	0.5
Total field costs	2,491.31	1.3
(C) Total cost	198,203.64	100
(D) Gross Returns	372,425.39	
(E) Net farm income	177,221.75	
(F) Return on Investment	1.89	

Source: Field Survey Data, 2023

Multiple linear regression model was used to examine the impact of Civid-19 on the output among cassava farmers in the study area. The results is presented in Table 4.3. The estimated parameters with positive signs indicates that variables contributes negatively to increase the output of farmers while positive signs is the reverse. The mean Covid-19 (X_1) had positive sign and significant at 1% probability level. This implies that a unit increase in Covid-19 led to decrease in output among the cassava farmers in the study area. Furthermore, the coefficients of education and extension contact also had expected positive signs and were significant at 1% and 5% probability levels respectively. This is an indication that change in education and extension contact influence the output among cassava farmers in the study area.

On the other hand, access to credit had negative sign and significant at 5% probability level. This signifies that as respondents increase in access to credit, it led to decrease on the farm output of the respondents. Results in Table 3, further revealed that 31% of variation of farm output among cassava farmers were caused by the explanatory variables included in the multiple regression model. While 69% was not explained by the explanatory variables.

The F-value was 2.45 and significant at 5% probability level, this implies that there is significant relationship between farm output and selected explanatory variables.

Table 3: Regression Results of impact of Covid-19 on the Cassava farmers output.

Variable	Parameters	Coefficients	Coefficients
Constant		93.647	93.647
		(1.194)	(1.194)
Covid-19	X_1	91.057	91.057
		(0.534)*	(0.534)*
Education Level	X_2	92.236	92.236
		(1.021)**	(1.021)**
Access to Credit	X_3	-6.992E-7	-6.992E-7
		(0’000)	(0’000)
Extension	X_4	0.223	0.223
		(0.124)*	(0.124)*
Input price	X_5	-0.165	-0.165
		(0.140)	(0.140)
Transportation	X_6	-0.424	-0.424
		(0.203)**	(0.203)**
Medication	X_7	0.036	0.036
		(0.037)	(0.037)
R^2		0.45	0.45
F-Value		1.78*	1.78*

Source: Field Survey Data, 2023**.**

Note: *** significant at 1% level, ** significant at 5% level and * significant at 10%

The study observed that farmers encountered various constraints in their cassava production activities. The constraints faced in the study area are presented in table 4.3. The results revealed that stealing (95%) ranked first, inadequate storage facility, shortage of inputs, unfavourable weather (85%) ranked second on the other hand, outbreak of disease ranked least the low ranking of outbreak of disease could be due to the fact that farmers in the study area may have several means of curtailing them.

Table 4: Distribution of respondents according to the constraints faced by farmers

Constraints	Frequency	Percentage
Stealing	19	95
Inadequate storage facility	17	85
Shortage of inputs	17	85
Inadequate transport facility	17	85
Lack of market for product	14	70
Unfavourable weather	14	65
Low produce price	12	60
Outbreak of disease	6	30
Total	115	

Source: Field Survey Data, 2023.

CONCLUSION AND RECOMMENDATIONS

Based on the findings of this study, it is concluded that Cassava farmers were in their active years, considering the age percentage of 70% for the range between 18 -55years in the study area, The study also indicated that Cassava production was a profitable enterprise, there is relationship between Covid-19 and farm output in cassava production and cassava farmers also faced some production constraints in the study area. Cassava production was found to be a profitable enterprise in the study area. Therefore, there is need to encourage practicing and prospective entrants into the business by making production resources available and accessible to the practicing farmers. This will enhance production, reduce widespread poverty, create job opportunity and better the lives of the citizenry. There is need for Government and Non-Governmental Organizations (NGOs) to coordinate more research into latest varieties of cassava, production techniques and Covd-19 to serve as extension packages since extension contact was found to affect the sustainability of farm level practices. Government and community leaders should try and establish more markets for cassava commodities for farmers to sell their products to avoid glut.

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EVALUATION OF SOME COWPEA (*VIGNA UNGUICULATA* L. WALP.*)* GENOTYPES RESISTANT TO STRIGA (*STRIGA GESNERIOIDES* WILD) IN KEFFI, NASARAWA STATE

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ABSTRACT
Striga generoides (Willd) is a major destructive parasitic weed of Cowpea (Vigna unguiculata L.) which causes substantial yield reduction in West and Central Africa. The trial involving 10 improved varieties in 2019 aimed at evaluating Cowpea genotypes resistant to Striga generoides was evaluated using Randomized Complete Block Design (RCBD) replicated three times at the Research Farm and Botanical Garden of the Department of Plant Science and Biotechnology, Nasarawa State University Keffi. Data collected on grain yield and yield components were subjected to Analysis of Variance (ANOVA). There was variability in number of days to 50% flowering among the genotypes studied. New sources of resistance were not found in this screening. However, the number of days to 50% flowering varied from 49 to 62 days with the mean of 51 days. The number of days to 50% flowering was highest in B5/15/2627(51 days) and was lowest in IT98k-205-8(49 days). The three resistant check (IT93K-593-2, IT99K573-1-1 and IT 98K-205-8-) had no emerged Striga shoot while varieties 291-171, 2472-154, and survita-2 were significantly different from that of susceptible check (IT90K-372-1-2) and they were identified as moderately resistant to Striga with low Striga shoot. Varieties (B2/19/2405-87, B1/18/2542 and B4/7/2338-20) were described as tolerant with high Striga shoots but no significant yield loss was observed. Therefore, the genotypes IT93K-593-2, IT99K573-1-1 and IT 98K-205-8 were confirmed as potential donor sources for incorporating resistant genes into adapted and farmer preferred varieties. The cultivars B2/16/2378, B1/13/2614-296 and B1/18/22542 were also identified as donor parents in breeding cowpea for yield improvement.

Keywords: *Genotype, Evaluation, Screening, Resistance, Variety, Striga and Cowpea*

INTRODUCTION
Cowpea (*Vigna unguiculata* (L.) Walp) is considered the most essential leguminous grain in the dry Savannas of tropical Africa. It is also known as the black- eyed pea or southern pea and is cultivated in a range of ecologies and cropping systems in the tropics. It originated from the semi-arid areas of West Africa and has been cultivated for human consumption for more than 4,000 years. (Tweneboah, 2000). Cowpea is a member of the Phaseoleae tribe of the Leguminosae family (Timko *et al.*, 2007). It was reported that Nigeria, being the largest producer of cowpea in the world accounted for 2.2 million tons of dried grain in 2010. The temperature varies 20-36 degree Celsius. The brief period of hot and dry weather occur between March to April with the temperature between 38-42 degree Celsius while the wet weather from May to October will long term annual rainfall of about 1040mm (Adejuwon, 2004). The average yield per hectare of cowpea in Nigeria was only 417kg per hectare (Abiola *et al.*, 2010). Regardless of the significance of black-eyed pea in West Africa; its production is still impeded by a myriad of abiotic factors. Biotic components, for example, pests and diseases, and parasitic weeds cause serious threat to cowpea production. The parasitic angiosperm *Striga gesnerioides* (Willd) is one of the significant limitations to cowpea cultivation particularly, in the Guinea Savanna agro-ecology. The parasitic weed *S. gesnerioides* is an obligate root-parasitic blossoming plant of the Scrophulariaceae family.
Methods need to be adopted for easy and less expensive for the identification cowpea genotypes that are resistant to *Striga gesnerioides* to boost production index of cowpea among local farmers. Due to ineffectiveness of the existing strategies for the control of infestation cause by *striga* specie for rural farmer the easier and inexpensive method of controlling *Striga* species is screening of cowpea genotypes for the best resistant to *Striga* infestation. The genotypes were classified as resistance or susceptible using the scale described by Emerchebe and florin (1997). The objectives of this study were to Identify: Cowpea genotypes resistant to *Striga gesnerioides* and Estimate genetic variability.

MATERIALS AND METHODS

The trials was carried out during the 2019 rainy seasons at the Research Farm and Botanical Garden of the Department of Plant Science and Biotechnology, Nasarawa State University, Keffi. The area is geographical located at latitude 0.833.766N and longitude 0.833.00E (Malunax, 2005).The climatic condition is characterized by two seasons: the dry and wet season. The rainy season last up to six-seven months and dry season usually last for about six months. Cold weather is usually experience between November to February which emanate from the influence of Northern-Easter Wind (Harmattan) which control the tropical continental air mass coming from the Sahara desert. The germplasm used comprised of 10 improved varieties from IAR Zaria. The experiment was conducted using Randomized Complete Block Design (RCBD) with three replications. Each plot comprised two rows of 3 m long with inter-row spacing of 0.80 m, and intra-row spacing of 0.50m. Three seeds were planted per hill and were thinned to one per hill two weeks after seedling emergence, resulting in a total of 14 plants per plot. Super single phosphate cowpea. Two hoe – weeding was done before *striga* emergence. The pesticide applied was dimethoate ($C_5H_{12}NO_3PS_3$) at pre-flowering and after pods formation to control insects and encourage pollination. Data was collected for Number of days from planting to 50% flowering, *Striga* shoots per plot, S*triga* density, *Striga* dry biomass, Grain yield, One hundred seed weight, Fodder yield.

RESULTS

The number of days to 50% flowering result shows that (Table 1) varied from to 49 to 62 days with a mean of 51 days. The number of days to 50% flowering recorded the highest result in B5/15/2627 2R (62 days) and was the lowest in IT98K-205-8 (49 days) throughout the period of observation. The three resistant checks (IT93K-693-2, IT99K-573-1-1 and IT98K-205-8) had no emerged *Striga* shoots m^{-2} (Table 1). The *Striga* shoots m^{-2} was low in lines of 291-171, 2472-154 and suvita-2 with values of 0.43, 0.74 and 0.87 respectively. These values were significantly different from that of the susceptible check IT90K-372-1-2 (7.84 *Striga* shoots m^{-2}). Varieties 2491-171, 2472-154 and Suvita -2 were identified as moderately resistant to *Striga*. Three lines of (B2/16/2378, B6/3/39274, and B3/13/2399-81A) described as tolerant had high *Striga* density (DS) of 2.53 to 8.77 *Striga* shoots m^{-2}, but no significant yield loss was observed. Cowpea grain yield varied from 54.88kg ha^{-1} to 691.63 kg ha $^{-1}$ for line 2510-192 and for line B1/18/2542 with an average yield of 246.12 kg ha^{-1}. Only five genotypes (6%) had yields exceeding 500 kg ha^{-1} while 35 (44%) had yield less than 200 kg ha^{-1}. The result (Table 1) shows that the yield reductions were significantly high (79% and 66%) in the susceptible cowpea lines as compared to the tolerant and resistant lines. In contrast, it was observed that the yield of tolerant cultivars (441.17 kg ha $^{-1}$ to 691.67 kg ha $^{-1}$) was higher than those of the resistant lines (276.63 kg ha $^{-1}$ to 380 kg ha $^{-1}$) *Striga* dry biomass (SDB) varied from 0.00 (IT93K- 693-2, IT99K-573-1-1 and IT98K-205-8) to 52.88 g (B6/2/2516). The overall genotype mean for SDB was 17.91 g per plot. One hundred seed weight (100-SW) varied from 7.3 g (2512-192) to 22.25 g (B4/13/2563-245-IR) with a mean of 14.91 g. Cowpea pod weight ranged from 50.93 g (2429-111) to 548.07 g (B1/18/2542 2R) with an average of 195.52 g per plot.

Table 1: Fifty Percent flowering, *Striga* Density, *Striga* dry biomass, Yield and yield Components Cowpea Germplasm Screened in Keffi (Rainy Season 2019).

Genotypes	50%FL (days)	DS (shoot m^{-2})	SDB (g)	GY (Kg/ha)	100-SW (g)	PW (g)
Resistance Checks						
IT93K-693-2	54.00	0.00	0.00	380.00	15.55	268.40
IT99K-573-1-1	50.33	0.00	0.00	340.74	17.70	170.27
IT98K-205-8	49.00	0.00	0.00	276.63	15.10	248.20
Moderately resistant						
IR2491-171	58.67	0.43	4.00	258.15	16.80	182.67
IR2472-154	57.00	0.74	4.45	141.73	16.35	158.67
Tolerant to *Striga*						
B2/16/2378	61.33	8.77	49.73	502.78	13.80	393.10
B1/13/2614-296	60.00	5.37	23.30	477.16	15.55	263.27
B1/18/2542	62.67	3.52	16.70	691.67	17.65	548.07
Susceptible Checks						
IT90K-372-1-2	57.33	7.84	25.83	150.37	15.55	111.70
IR88-63	61.00	3.89	18.83	230.00	12.75	131.03
Grand mean	51.40	3.06	14.30	246.12	14.91	195.52
Total LSD(p<0.05)	5.34	3.75	19.39	193.68	1.44	156.65
Total CV%	5.58	69.04	67.10	50.06	6.01	51.46

CV: Coefficient of variation; LSD: Least Significant Difference at P=0.05; 50% **FL**: days to 50% flowering; **DS:** *Striga* density; **PW:** Pod Weight; **SDB:** *Striga* dry biomass; **GY:** cowpea grain yield; **100-SW**: one hundred seeds weight.

Table 2 shows that the mean squares of the traits for the treatments at 50% flowering, *Striga* density, *Striga* dry biomass, Grain yield, Pod weight and one hundred seeds weight were significantly difference at 0.0001 probability level respectively.

Table 2: Mean squares of the traits

Sources	DF	50%	DS	SDB	GY	PW	100-SW
Block (Rep)	9	13.67	9.68	86.82	22893.85	13072.69	0.78
Treatments	9	62.42***	13.01***	332.44***	59224.66***	33497.39***	16.90***
Error	27	10.90	5.37	145.95	14718.74	1024.81	0.79
Total	36						

(***): Significant at 0.0001 probability level

DISCUSSION

There was variability in the number of days to 50% flowering among the genotypes. This is in line with the findings of Tiwari *et al.,* (2019).This variability may be due to climatic conditions or the genetic background of the varieties. In this study the number of days to 50% flowering ranged from 49 to 62 days after planting with a mean of 51 days while it varied from 32.72 to 54.84 days after planting (DAP) with a mean of 44.31 DAP in the study by Egbe *et al.* (2010). This showed that there were no extra early maturing varieties in the germplasm screened. Only three genotypes (IT99K-573-1-1 and IT98K-205-8) include as resistant checks were free of *striga* emergence in this study. The resistance in IT93k-693-2 confirmed the result of Singh (2002) and Boukar *et al*. (2004) who reported that this genotype was resistant to all the five known *striga* races in Africa. Recently, Tignegre (2010) found similar result with the races prevailing in Burkina Faso. The resistance observed in IT99K-573-1-1 and IT98K-205-8 in line with the finding of Tchiagam *et al.* (2010) who observed no *Striga* emergence from the two genotypes screened for resistance to race 5 in Cameron. Though, these genotypes were highly resistant to *Striga* in this studies there grain yields were very low as compared to their yields obtained from studies in Cameroon. IT99K-573-1-1 and IT98K-205-8 yielded 1042.75 kg ha $^{-1}$ and 871.10 kg ha^{-1} respectively in plot 1versus 340.74 kg ha $^{-1}$ and 276.63 kg ha $^{-1}$ in plot 2. The line IT93K-693-2 yielded 911.60 kg ha $^{-1}$in this study. These differences observed may be attributed to genotypes response to climatic conditions and soil types. The genotypes are well adapted to the conditions in both plots.

CONCLUSION

New sources of *Striga* resistance were not found in this screening. However, the genotypes IT93K-693-2, IT99K-573-1-1 and IT98K-205-8 were confirmed as potential donor sources for incorporating resistance genes into adapted and farmer preferred varieties. The cultivars B2/16/2378, B1/18/2542 and B1/13/2614-296 were identified as donor parents in breeding cowpea for yield improvement. The best combination of crosses to incorporate *Striga* resistance into adapted lines would be IT93K-693-2 as donor parent and the top three farmers' preferred varieties while IT90K-372-1-2 and IR88-63) as recurrent parents.

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IMPACT OF NATIONAL ROOT CROPS RESEARCH INSTITUTE (NRCRI) ON AGRICULTURAL PRACTICES IN TWO LGAS IN THE UMUAHIA AGRICULTURAL ZONE, NIGERIA

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ABSTRACT
The study on the impact of National Root Crops Research Institute (NRCRI) on agricultural practices was conducted in Umuahia agricultural zone, Abia State, Nigeria. By purposive and random sampling techniques, ninety (90) farmers were selected for the study. A well-structured questionnaire was used to elicit information from the respondents. The data was analyzed using descriptive statistics such as frequency counts, and percentages. The findings revealed that a majority of the respondents were in their active stage of their life in which they can effectively adopt improved innovations that would change their farming practices and result in increased productivity. However, most of the farmers recorded high impact in their farming activities and productivity through the adoption of improved farm technologies from NRCRI. It was recommended that the institute should sustain the esteemed record of impacting positively on the farming activities and productivity of the farmers in the study area. Efforts should be made by the institute to impact positively on the farming activities and productivity of over 90% of the farmers in the study area.

INTRODUCTION
The National Root Crop Research Institute (NRCRI), which has the mandate for the genetic improvement root and tuber crops such as yam, cassava, cocoyam, sweet potato, Irish potato and ginger, rizga (Livingstone potato), sugar beet and Turmeric has great potential for contributing to national economic development. The Institute also researches into the farming systems and researh-extension farmer input linkages (REFILS) for crop cultivation techniques, storage, processing and utilization of the crops for farmers in the south-east zone of Nigeria. The Institute runs a diagnostic survey of the farming systems of the zone to obtain information on status of agricultural activities and to identify production constraints and opportunities, conduct of up-stream (on-station) research to tailor down commodity research results to suit farmers' conditions, conducts Monthly Technology Review Meetings (MTRMs), where scientists from research institutes and universities train the Subject Matter Specialists (SMSs) from the state Agricultural Development Programmes on improved technologies (Udealor, 1999). The Institute also provides training of middle level agricultural workers, awarding National Diplomas and Higher National Diplomas and providing specialized vocational training to farmers.
The National Root Crop Research Institute (NRCRI) helps in the development and transfer of production packages-crop varieties, optimum spacing, optimum rate and time for fertilizer application, weed control measures and crop compatibilities, stacking methods in yam-based systems, harvesting for maximum productivity of technologies, weed control in root and tuber crops-based mixtures, cocoyam/maize/pigeon pea at 2.0m inter-row and 1.0 inter-row spacing and development of complementary use of both cassava composite root meal and cassava composite meal with commercial feed in the feeding of broilers and laying birds (Udealor, 2001). This study was therefore initiated to to assess the impact of NRCRI on agricultural practices in the Umuahia agricultural zone, Abia State, Nigeria.

METHODOLOGY
The study was conducted in Umuahia Agricultural zone in Abia State, Nigeria. The zone is made up of six (6) Local Government Areas: Umuahia North, Umuahia South, Isiala Ngwa North, Isiala Ngwa South, Ikwuano and Umunneochi. About 60-70% of the population are engaged in agriculture primarily for crop production and animal rearing (Nnamerenwa, 2012). Umuahia North and Ikwuano Local Government were purposively selected due to their proximity to NRCRI Umudike. A total of 90 respondents were randomly selected and interviewed. Forty-five (45) farmers were chosen from three (3) communities in each of the two (2) Local Government Areas selected for the study. The farmers were selected based on their involvement in root and tuber crops production. Both qualitative and quantitative information was elicited from the farmers using a well-structured questionnaire and the data collected was analysed with descriptive statistics like mean, frequency, percentage and Likert-scale methods.

RESULTS AND DISCUSSION

Demographic characteristics of Farmers: (n=*90)*

Table 1 provides a frequency distribution of the respondents based on various demographic variables. The results show that majority of the sampled respondents were female (62.2%), while men constituted 37.8% implying that women are more involved in the production of root and tuber crops more than men in the study area.

The mean age of the respondents in the study area is 48.8 years implying that agriculture as a business is dominated by middle aged people. The result further shows that the majority of the respondents (64.5%) were married. This may be an added advantage in the sense that supportive spouses could be a major source of encouragement and motivation in ensuring that innovations are adopted in the study area. The result also indicates that more than half (61.1%) of the respondents have a household size of 6-10 members. This result indicates that the respondents had household sizes above average. This number of household members may lead to increased output and income generation from their farms. In terms of education, about (37.8%) of the respondents attained primary, secondary (32.2%), 20% had tertiary educational while 10 percent had no formal education. The farmers may thus be considered literate. This is an advantage in that education should assist these farmers to understand better the farming innovations being introduced to them. This is consistent with the findings of Adedoyin *et al*. (1999) who identified education as a foundation for farmers' use of agricultural innovations. The result shows that the mean farm size is 1.8 hectares. Majority of the respondents (86.7%) had farm sizes of 2 hectares and less, implying that the study area is characterized by small, fragmented and non-contiguous farm holdings. The small farm sizes may also affect their farm output and hence low farm income. Only 28.9% had less than 5 years of farming experience, 53.3% had between 6-10years of experience, 10.1% had between 11-15 years' experience, while 6.7 percent had above 16 years of farming experience in the study area.

Table 1: Demographic characteristics of the Farmers: (n=90)

Variables	Frequency	Percentage
Sex:		
Male	34	37.8
Female	56	62.2
Age:		
≤30	21	23.3
31-40	35	38.9
41-50	28	31.1
<51	6	6.7
Mean	48.8	
Marital status:		
Single	3	3.3
Married	58	64.5
Divorced	9	10
Widowed	20	22.2
HH size:		
≤5	27	30
6-10	55	61.1
>11	8	8.9
Ed**ucational Level:**		
No formal Edu.	9	10
Primary	34	37.8
Secondary	29	32.2
Tertiary	18	20
Farm Size:		
≤1	27	30
1.01-2	51	56.7
2.01-3	8	8.9
>3	4	4.4
Years of experience in business:		
≤5	26	28.9
6-10	48	53.3
11-15	10	10.1
>16	6	6.7
Mean	16.5	

Source: Field survey 2017.

Farmers Understanding of Reasons for the Establishment of NRCRI Umudike.

The result for Table 2 shows that 35.6% of the respondents understood the establishment of NRCRI Umudike by the government to be for the identification of solutions for major constraints to root and tuber crops production, followed by the development and distribution of improved planting materials to farmers to increase their agricultural productivity (31.1%). 20% of the respondents had the understanding that NRCRI Umudike was established to advice farmers on the best agronomic practices to adopt and to assist farmers in the control of post-harvest losses (13.3%). The result implies that the respondents had better understanding of the reason behind the establishment of NRCRI Umudike and would better assess the performance of the Institute in meeting up with such mandate.

Table 2: Distribution according to reasons for the establishment of NRCRI

Reasons for the establishment of NRCRI	Frequency	Percentage
To identify solutions for major constraints to Root and Tuber crops production	32	35.6
To advice farmers on the Best Agronomic Practices	18	20
For development and distribution of improved planting materials	28	31.1
To assist farmers in the control of post-harvest losses	12	13.3

Source: field survey 2017

Farmers Visitation by NRCRI Extension Staff

Table 3 shows that majority of the farmers (72.2%) had at most three visits from the extension staff of the Research Institute. The mean number of visits to the farmers by staff of Research Institute was once per farming season. This implies that in a year, most of the farmers had very few visits from the extension staff of NRCRI Umudike and may therefore not have benefitted from the knowledge they are supposed to gain from them. Knowledge is in form of new agricultural innovations and technologies, improved crop varieties, better farming practices and advice on better farm management practices may not have been disseminated effectively to the farmers in one visit only.

Table 3: Respondents according to number of NRCRI staff visits they received.

Number of visits	Frequency	Percentage
≤ 3	65	72.2
4-6	22	24.4
>7	3	3.3
Mean	1.8	

Source: Field survey 2017.

Reasons for Visit by NRCRI Extension Staff to the Farmers

The result in table 4 shows that majority (44.4%) of the farmers were visited by the extension staff only to distribute improved farm inputs to them. This was followed by extension staff (24.4%) who visited the farmers to establish demonstration farms, (20%) who visited the farmers to invite them for seminar, and, (10%) who visited the farmers to inspect their farms**.**

Table 4: Distribution according to their reasons for visit by NRCRI extension staff

Reasons for visit	Frequency	Percentage
To supply improved farm inputs	40	44.4
To invite for seminar	18	20
Establishment of demo farm	22	24.4
To inspect farm	10	11.1

Source: Field survey 2017.

Level of Impact of NRCRI on Agricultural Practices and Productivity of Farmers in the study area.

Table 5 showed that majority (44.4%) of the farmers recorded high improvement in their farming activities and productivity despite their access to improved farm inputs from the research institute, while only 38.9% of them recorded low improvement. However, fewer (16.7%) did not record any significant improvement in their farming activities and productivity of the farmers in the study area.

Table 5: Level of impact of NRCRI on agricultural practice and productivity of farmers

Level of impact	Frequency	Percentage
High improvement	40	44.4
Low Improvement	35	38.9
No Improvement	15	16.7

Source: Field survey 2017.

CONCLUSION AND RECOMMENDATION

The study findings revealed that most of the respondents were in their active stage of life in which they can effectively adopt improved innovations that would change their farming practices and result in increased productivity. Majority of the farmers understood the reason for the establishment of NRCRI Umudike by the government to be mainly for the identification of solutions for major constraints to root and tuber crops production and for developing and distributing improved farm inputs to farmers in other to increase their agricultural productivity. Most of the farmers recorded high improvement in their farming activities and productivity through the adoption of improved farm technologies from the institute. The institute impacted positively on the agricultural activities and productivity of farmers in the study area.

This study therefore recommends that the extension staff of NRCRI should be encouraged to take the farming-visiting aspect of their training very seriously especially in the study area. Efforts should be made by the institute to impact positively on the farming activities and productivity of over 90% of the farmers in the study area.

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PRODUCTION OF APPLIED DESIGN ON FABRIC USING BANANA STALK GUM

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ABSTRACT

The study was on the production of fabric design using banana stalk gum. The practical was carried out at the Department of Home and Rural Economics, Oyo State College of Agriculture and Technology, Igboora. The objectives were to study the structure and physical properties of procured banana stalk gum, applied design on fabrics using banana stalk gum and determine the level of acceptability of fabrics produce. The data was collected through well-structured questionnaires administered to twenty one (21) respondents (staffs and students) to receive their view about the product produced in term of colour, texture, appearance, design, functionality and overall acceptability of the products. The data collected from this study were used to analyze the frequency count and percentage to explain the characteristics of the respondents with the use of table to relate one variable to another. From the result, the fabrics produced using banana stalk gum was rated in the order: extremely, like very much, like moderately and like slightly in term of colour, texture, appearance, design, functionality and overall acceptability. From the finding, it was observed that the fabrics produced with banana stalk gum is well acceptable by the respondents. The findings recommend that sap from banana tree which contains tannins can be used to make fabric design. Also, Farmers should be encouraged by the government to embark in production of banana trees for its sap (tannis) collection like sugar cane which is produced because is third content. (Sucrose).
Lastly, the youth should be trained in line with the usage of tannins to produce designs on fabric for the production of different dresses.
Keywords: *Fabric, Banana, Banana Stalk Gum, Design, Tannis*

INTRODUCTION

Natural fibres have under intensive study worldwide due to their continuous supply, safe handling biodegradability and nontoxicity. They are usually low-cost fibres with low density with high specific properties (Santosha et al., 2018). Banana belongs to the family Musaceae, genus Musa, is a general term embracing a number of species or hybrids in this genus. Currently, throughout the world, it is widely cultivated in tropical and subtropical regions as one of the important staple food and commodities. (Boonruangrod, 2009). Almost each and every part of banana plant gives fibres of various strength, colour and long staple length. It is also sustainable, biodegradable, strong, fine, and could be an alternative to silk (Ebisike *et al.*, 2013). Subsequently a dead waste product from banana production, which is already being grown on a large scale globally, can be turned into fabric. Banana stalk gum can be made into a textile that can be used in multiple applications. However, it is a very obscure textile in the fashion industry, even with the rise in sustainability awareness. Further the companies that have been using banana stalk gum have not been doing so for a lengthy time. This study therefore aimed at producing textile from banana stalk gum.

MATERIALS AND METHOD

This research work was carried out in the department of Home and Rural Economics, Oyo State College of Agriculture and Technology, Igboora, Oyo State.

Research Design

The design for the study is a combination of experimental and survey design methods.

Population of the Study

The population of the study was the total number of student in the department of Home and Rural Economics which is 205 students and 10 lecturers from the department of Home and Rural Economics, Oyo State College of Agriculture and Technology, Igboora.

Sample Size and Sampling Technique

Random sampling techniques was used to select the sample size which was 10% of students and 10% lecturers was used for data analysis which is 20.5 students. Therefore, the research used twenty one (21) respondents

Procedures for Data Collection

The data was collected through the use of some samples of fabrics design with banana stalk gum and well-structured questionnaire was also administered to the respondent to receive their view about the product produced.

Materials for the production of fabrics design using banana stalk gum

Materials	Quantity (ies)
• Fabric	15 yards
• Dyes	150 g
• Caustic soda	50 g
• Hydrosulphite	150 g
• Corn Starch	50 g
• Scissors	1
• Hand gloves	2
• Bucket	1
• Bowl	1
• Stove/Gas	1
• Kettle/Pot	1
• Stirring rod	1
• Nose cover	1
• Starch	50 g

Production Procedure

1. Washing of the fabrics to remove industrial starch and dry
2. Application of banana stalk gum to the fabrics

3. Prepare the chemical
4. Dye the fabric

5. Wash thoroughly and dry
6. Application of starch to the fabric and sundry
7. Ironing of the fabric
8. Packaging of the design fabric

Method of Data Analyses

Primary data obtained for the study was analyzed and presented using tables. The data collected was synthesized for any ambiguities that may exist, coded and analyzed using the Statistical Package for Social Science (SPSS).

Presentation of Analyses and Discussion of Findings

Table 4.1 Distribution of Result Generated from Tie-Dye Produced using Banana Stalk Gum

Sample	Colour	Texture	Appearance	Design	Functionality	Overall acceptability
	F (%)	**F (%)**	**F (%)**	**F (%)**	**F (%)**	**F (%)**
Like extremely	11 (52%)	11 (52%)	16 (76%)	10 (48%)	11 (52%)	20 (95%)
Like very much	8 (39%)	7 (33%)	5 (24%)	7 (33%)	9 (43%)	1 (5%)
Like moderately	2 (10%)	3 (15%)	-	2 (10%)	1 (5%)	-
Like slightly	-	-	-	2 (10%)	-	-
Neither like nor dislike	-	-	-	-	-	-
Dislike slightly	-	-	-	-	-	-
Dislike moderately	-	-	-	-	-	-
Dislike very much	-	-	-	-	-	-
Dislike extremely	-	-	-	-	-	-
Total	**21 (100%)**	**21 (100%)**	**21 (100%)**	**21 (100%)**	**21 (100%)**	**21 (100%)**

Source: Researcher's Survey, 2022

Distribution of Result Generated from Tie-Dye Produced using Banana Stalk Gum

Colour:- The table shows that 52% of the respondents scored the colour of the tie-dye as like extremely, 39% scored it as like very much while the remaining 10% of the respondents scored it as like moderately. This show that majority of the respondents accept the colour of tie-dye produced with banana stalk gum as like extremely, like very much and like moderately.

Texture:- the result reveals that 52% of the respondent scored the texture of the tie-dye produced with banana stalk gum as like extremely, 33% of the respondents scored the texture of the tie-dye as like very much while the remaining 15% of the respondent scored the texture of the tie-dye produced with banana stalk gum as like moderately.

Appearance:- The table below shows that 76% of the respondents scored appearance of the tie-dye as like extremely while the remaining 24% of the respondents scored it as like very much, in term of appearance of tie-dye produced with banana stalk gum.

Design: the table below shows that 48% of the respondents scored the design of the tie-dye produced with banana stalk gum as like extremely, 33% of the respondents scored it as like very much, 10% scored it as like moderately while the remaining 10% scored the design of the tie-dye produced with banana stalk gum as like slightly.

Functionality: 52% of the respondents scored the functionality of the tie-dye produced with banana stalk gum as like extremely, 43% of the respondents scored it as like very much while the remaining 5% scored the functionality of the tie-dye as like moderately.

Overall Acceptability:- the result in the table below shows that 95% of the respondents scored the overall acceptability of the tie-dye produced with banana stalk gum as like extremely, while the remaining 5% said they like it very much. This reveals that there is acceptability of the tie-dye produced with banana stalk gum among the sampled respondents.

CONCLUSION AND RECOMMENDATIONS

In line with the findings of this study, the following conclusions and recommendations were made;

i. Banana stalk should be made use of in the production of quality fabrics
ii. It is recommended that sap from banana tree which contains tannins should be used to make best fabric design.
iii. Farmers should be encouraged by the government to embark in production of banana trees for its sap (tannis) collection like sugar cane which is produced because is third content. (Sucrose)
iv. The youth should be trained in line with the usage of tannins to produce fabric and to produce different dresses.

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DETERMINANTS OF TEA COMPETITIVENESS IN NIGERIA: A DYNAMIC PANEL APPROACH

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ABSTRACT
This paper aimed at understanding the motivating force behind competitive tea production in Nigeria. Secondary data from Mambilla Beverages Nigeria Limited annual reports were used. A dynamic panel regression method was used to examine factors influencing competitiveness of tea productions in Nigeria. The results showed that training ($p \leq 0.05$), working years ($p \leq 0.05$) and labour cost are major($p \leq 0.05$)determinants of tea competitiveness while factors such as gender, household size, age and religion are not critical to tea competitiveness.
Keywords: *Competitiveness, Dynamic Panel Regression, Private Cost Ratio, Tea, Nigeria*

INTRODUCTION
Tea (*Camellia sinensis*) is one of the most popular lowest cost beverages in the world; it is consumed by people from all races and ages (Raj, 2020; FAO, 2022). Tea demand is increasing around the world, resulting from increased sensitization of the health benefit, new client and new market; owing to this increasing demand, tea is considered a major component of world beverage market (Raj, 2020). In the past decades, the tea industry worldwide recorded speedy progress, with a rising amount of clients worldwide as well as many domestic markets (FAO, 2022). The international tea market is described by increasing income and tremendous revenue sectors and related health beneficial potentials, consumers increasing demand for natural organic, locally sourced drink in varied flavor, blend and environments. There is also, growing interest in quality specialty teas, locally sourced with particular flavours, and growing numbers of young customers and an emerging middle class.

The Federal Ministry of Agriculture and Water resources introduced tea production to Nigeria in 1972. Research activities onto the potential of tea growth on the Mambilla Plateau was carried out and report submitted in 1973 which recommended among other things the establishment of a tea estate and a land area of 700 hectares were acquired and in 1975, the first tea estate was established by the government. Tea varieties were imported from Kenya and research into development and establishment of clonal material commences. Commercial production of tea started in 1981 on the Mambilla plateau of Taraba State. To meet the processing demand of the tea company, the arrangement was made for out growers small scale farmers who sell their green tea leaves to the company.

The annual demand for green leaves increases with increases in processing companies in the country. This is equally accompanied by increased consumption leading to increase demand for made tea. On the average, there is annual tea requirements of ten million (10,000,000) kilogram in Nigeria, out of which only 1,640,000 Kilogram (10%) of this requirements is being met annually on the Mambilla Plateau (Omolaja *et al.*, 2012;Oluyole,*et al*, 2017; NBPC, 2016, 2017, 2018, 2019). Government intervention in tea sector resulted into expansion of areas cultivated with tea on the Plateau thereby more than double tea output in Nigeria. Also, the increases in areas cultivated with tea addresses the problems of dependence on tea importation and remove the heavy burden of foreign exchange outflow resulting from tea importation into the country (Adulagba, 2010). Nigeria now becomes' exporter of tea and earn foreign currencies and increased profitability; Tea production, processing and marketing has great potential for economic growth, hence the need for assessing determinants of competiveness to understand point of entry (Oluyole *et al.,* 2017, 2018; NBPC, 2019).

CONCEPTUAL REVIEW
CONCEPT OF COMPETITIVENESS
Competitiveness has been the basis of analysis when there is interest on issues bordering on allocation of assets in order to guarantee social welfare, better living standards and great employment rates as well as determining what a sector contributes/can contribute to the country's GDP (Ilchenko, *et al*, 2021). The Organization for Economic Cooperation and Development (OECD) defined competitiveness as "the ability of corporations, businesses, states, countries to produce, while trading in international market, a reasonably high income level and factor employment levels on a sustainable basis" (Saptana, *et al*, 2022). The EC (2018) defines competitiveness as "the ability of a country to provide its inhabitants with high

and increasingliving standards and high employment rate on a sustainable basis". Others relate this meaning to profitability (Long, 2021).

Competitiveness is a relative measure, depending on the purpose of study, the level of analysis, and the commodity being study. Several methodologies have been used to estimate competitiveness (Saptana, *et al*,2022; Dildora Nurmatovna *et al.*, 2020; Long, 2021; OCDE, 2021). Broadly, competitiveness has been classified into two main discipline namely: The Neoclassical economies who place emphasis on trade and export and measure competitiveness with comparative advantage, exchange rates and exports or imports indices (Yulin, 2021) and the Strategic Management that focuses on firm's structure and strategy, as well as the firm's competitiveness using indicators such as productivity and efficiency (Raji and Omotosho, 2006).This study adopted Porter's measure of competitiveness, competitiveness advantage described as country ability to produce a good or services at a lower cost domestically; approach described by Monke and Pearson, (1989)

Theoretical Framework

Theory of Competitive Advantage

The theory of competitive advantage was proposed by Michael Porter in the year 1985 and the theory seeks to address some of the criticisms of comparative advantage. Competitive advantage is the strategic advantage one business entity has over its rival entities within its competitive industry (Porter, 1985; Pressman, 1991). Porter believes that to get more than its fair share of profits, a company has to be able to do things that its competitors cannot do thus making such a company to have a competitive advantage over the others. There are two drivers of competitive advantage as far as Porter is concerned: cost advantage and differentiation. In cost advantage, one needs to incur lower costs than any other competitor. That advantage allows one to either price his/her products lower than anyone else or just to match prices and take the difference in profits. Differentiation just means meeting some customers 'need better than any competitor and getting a premium price in return. Porter identified attributes of nation which either promote or impede its competitive advantage and this includes factors condition, demand conditions, firm strategy, structure & rivalry, government role and element of chance.

Factor conditions: When a country is endowed with human resources, physical resources, knowledge resources, location, capital resources and infrastructure, it plays a significant role in determining its national competitive advantage. Also, basic factors such as natural resources, climate, advanced factors such as skilled labour, communications infrastructure, and technology are the crucial determinants of the nation's capabilities and competitiveness. Advanced factors are declined by the efforts of the individuals, firms, institution and government in a country.

Demand conditions: The demand conditions in home market are important in stimulating domestic firms to undertake innovation and improve quality of products. When domestic buyers are sophisticated, a pressure in the market is created for the domestic firms to meet high standards of quality demanded. Government's role: This can influence each of the other determinants of competitiveness. Government can influence the supply conditions of key factor s of production, demand conditions in the home market, and competition between firms. Government interventions can occur at local, regional, national or supranational level. Firm strategy, structure and rivalry: The way in which companies are created, set goals and are managed is important for success. But the presence of intense rivalry in the home base is also important; it creates pressure to innovate in order to upgrade competitiveness. Element of Chance events: These are occurrences that are beyond the control of a firm. They are important because they create discontinuities in which some gain competitive positions while others lose. In the present study, productivity, economies of scale, factor conditions, demand conditions and ability to obtained adequate price are major determinants of competitiveness of the value chain which are embedded in Porter competitive advantage theory.

METHODOLOGY

Secondary data for tea production 2015 to 2018 from Mambilla Beverages Nigeria Limited annual report was used. Competitiveness of tea production was determined using; a dynamic panel through the system generalized method of moments (SGMM) and combined with Policy Analysis Matrix (PAM) specified as follows:

$$PCR_{it} = \alpha_1 PCR_{it-1} + \alpha_2 X_{it} + (\varepsilon_i + \mu_{it}) \qquad (i)$$

Where:

PCR is the ratio of domestic cost and to value created at private prices, *i* indicate a vector of cross-section of producer at period *t*., X represents a vector of exogenous variables, indicators like religion, gender, training, age, and household size, number of household income earners, labour cost, and working years.,ε_i is an error term capturing the unobserved and fixed time-specific effect of producers, μ_{it} is an endogenous error term (Roodman, 2009; Azimi, 2022). Furthermore, equation 1 assumes a random walk, and PCR is persistent.α_1 yield unbiased and efficient in finite samples through the system GMM rather than the differenced GMM (Arellano and Bover, 1995; Blundell *et al*., 2001; Roodman, 2009), especially since the data of the variables are collected for specific period.

This study utilized the system generalized method of moments (SGMM) and conducted various investigations to select the best suitable model specification. Estimation of SGMM can either be one-step or two-step (Hansen, 1982; Erickson and Whited, 2002). While the One-step SGMM involves estimating the parameters of the model in a single step by minimizing the moment conditions based on the data, the two-step GMM takes the process further by minimizing the distance between the moment conditions and the sample moments of the estimated parameters (Arellano and Bond, 1991; Wooldridge, 2010). However, the one-step GMM is adopted in this study because the model is correctly specified, and the moment conditions have no measurement errors. Also, this study relies heavily on efficient and faster computation of parameters, which is a major advantage of one-step SGMM over the two-step SGMM.

Furthermore, to examine the presence of serial correlation in the residuals, the Arellano-Bond test is utilized while assuming the absence of order serial correlation of first (AR1) or second (AR2) (Roodman, 2009). The Hansen test of over-identifying restrictions to detect potential endogeneity bias and specification issues during model estimation (Hoeffler *et al.,* 2001) was employed in this study. Following Roodman (2009), the instrument matrix is collapsed to prevent having numerous instruments, which may arise from the Arellano-Bond estimation approach of using a lagged level as valid instruments.

RESULTS AND DISCUSSION

The result of the system generalized methods of moment (SGMM) approach is as presented in Table 1. From the table, the result of difference-in- Hansen test statistics show that the null hypothesis which stated that there is no serial relationship between instruments and error terms cannot be rejected, signifying that the over-identifying restriction are valid. Also, the Arellano- Bond test for AR(1) provides strong evidence that the residuals are negatively correlated which corroborate the first-difference process in the SGMM methods. Similarly, the null hypothesis of zero correlation in the first differenced at order 2 (AR2) is not rejected, a necessary requirement for constant results.

Adopting the policy analysis matrix approach to PCR values, the higher the PCR (PCR >1) the smaller the competitiveness. Hence, a positive calculated figure signifies that the independent variable rises the PCR and has a negative effect on competitiveness. However, a negative estimated coefficient shows that the explanatory variables decreases the PCR and thereby has a positive influence of competitiveness. From table 1, the PCR value is less than 1, indicating that tea production is competitive in Nigeria.

The result from the table further shows that, the estimated coefficient of training variable is significant at 5% level. The result show that each additional cost incurred in getting trained increases competitiveness. Tea production requires continuous training to improve performance, and efficiency in operations. Training lead to access to economic benefit, improved technology, information, improved methods of operations, reduction in various costs and consequently, higher competitiveness.

The result of the SGMM also shows that number of working years significantly influenced competitiveness at 5% level. The higher the number of years used in tea production, the more the competitiveness. This is a result of training attended and improvement leant over the years which affect the profitability of actors. The result equally shows that labour cost coefficient is significant at 5% levels. This is an indication of strong relationship between labour costs to increase in competitiveness. An additional cost incurred on labour increases profitability. The labour cost involved in tea activities is small as confirmed by the PAM results and this increase profitability.

Table 1. System GMM Assessments for Tea Competitiveness.

Dependent Variable: SCB		
Explanatory Variables	**Coefficient**	**Standard Error**
PCR_{t-1}	0.1865***	0.0573
Christian	0.5728	0.4496
Training	-0.8994**	0.4204
Working Years	-0.0654**	0.0277
Age	0.0003	0.0283
Household Size	0.0062	0.0680
Income Earners	0.0758	0.1307
Male	-0.6050	0.4729
Labour Cost	-0.00003**	0.00001
Observations	301	
Year and System Control	Yes	
Number of Instruments	4	
F Statistics	5.092	
Arrellano-Bond test AR (1)	-4.81	[0.000]
Arrellano-Bond test AR (2)	-0.55	[0.579]
Hansen Statistics	9.17	[0.103]

Source: Field survey, 2021 Note: ** and *** indicate 5% and 1% significance levels, respectively. Values in the squared bracket are probability values.

CONCLUSION AND RECOMMENDATION

Result of the dynamic SGMM showed that, training, number of working years, and labour cost are main determinants of competitiveness. The estimates further revealed that age, gender, household size are not important factor for tea competitiveness. It is therefore recommended that government should enhance the participation of actors in tea value chain in relevant training to increase the competitiveness of tea sector.

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CHANGING THE FORTUNES OF SMALLHOLDER FARMERS IN THE FACE OF ECONOMIC DIFFICULTIES, INSECURITY AND CLIMATE CHANGE

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ABSTRACT

The agricultural sector's significance as a driver of economic growth and development has led successive administrations in Nigeria to prioritize interventions in this domain since the 1970s. The understanding of agricultural pivotal roles, including food supply, raw material provision, job creation, savings, tax generation, and foreign exchange earnings drives this focus. The sector's importance is underscored by the fact that, without developing agriculture, achieving economic growth in Nigeria is nearly impossible due to its 70% population employment. The paper discusses several challenges facing smallholder farmers in Nigeria, focusing on economic difficulties, insecurity, and the impact of climate change. It highlights the vital role of farming in feeding the global population and introduces the various ecological and economic challenges farmers have historically faced. The economic overview section emphasizes the economic hardships in Nigeria, including income loss, inflation, and unemployment, which impact farmers' ability to access financial resources and improve their yields. It points out that despite some projected economic growth, issues such as inflation and reduced liquidity could continue to affect the non-oil sectors and macroeconomic stability. The socioeconomic situation in Nigeria, characterized by poverty and limited human capital development, is also discussed. Climate change is discussed as another significant challenge affecting Nigerian farmers. The paper notes that rising temperatures, drought, and changing rainfall patterns impact agricultural productivity and food security. The effects of extreme precipitation events and flooding on agriculture are highlighted, with recent flood events causing displacement, destruction of farmland, and potential increases in food prices. The paper further discussed the Prospects of Agricultural development and Pro-poor intervention by the Federal Government of Nigeria through the Central Bank of Nigeria. Climate Smart Agriculture (CSA) and Good Agricultural Practices (GAP) are highlighted, with CSA addressing food security and climate change challenges, aiming for increased productivity, enhanced resilience, and reduced emissions. GAP involves voluntary audits to ensure safe and sustainable food production. While challenges like climate change and insecurity persist, government policies, financial support, improved inputs, and technological advancements are proposed as solutions. Farmers' resilience and persistence remain crucial in sustaining Nigeria's agricultural sector's contributions to the national economy and food security. The paper highlights the multifaceted challenges faced by smallholder farmers in Nigeria, encompassing economic difficulties, insecurity, and the effects of climate change. It underscores the urgent need for interventions to support farmers in overcoming these challenges and improving their livelihoods.

***Keywords**: Climate Smart Agriculture, Good Agricultural Practices, Food security, insecurity, climate change, Pro-poor intervention*

INTRODUCTION

Farming is indubitable a noble and vital profession; because without farming, the whole world would starve to death. However, farming as we know is a uniquely challenging profession. For Millennia, farmers have struggled to find creative solutions to a variety of ecological and economic challenges. The various challenges affect feeding an expanding global population to meeting rising demands which involves producing more foods on lesser acres to the detriment of using less arable land, producing high quality and bountiful yields, rearing healthy and numerous livestock. Throughout the record of history there has never been a time when farmers had absolutely no worries. Till date farmers are faced with those perennial risk, yet they have been survivors and most of you farmers are no exceptions.

According to Mbenka and Mbah (2016), smallholder farmers operate at subsistence, smallholder level, with intensive agriculture being uncommon. A characteristic feature of the agricultural production system in Nigeria is that a disproportionately large fraction of the agricultural output is in the hands of these smallholder farmers whose average holding is about 1.0 - 3.0 hectares. According to the Federal Office of Statistics (1999) smallholder farmers are those with land holdings ranging from 0.1 to 4.99 hectares. Access to new enhanced technology is extremely limited, and their overall situation does not always warrant real investments in cash, inputs, and labor. These farmers lack agricultural information and this is a factor that encourages ignorance of contemporary farm technologies in the farmers, consequently the issue demands more attention than it already gets. These farmers also face high production costs, which affect both commercial and smallholder farmers, as well as other restraints affecting smallholder farmers. The Nigerian Small holder farmers have limited access to loans, which significantly decreases their production (Mgbenka and Mbah, 2016).

Economic Overview

Economic hardship resulting from income loss, recession, unemployment, price inflation, and economic insecurity affects a country generally. As these and many other lapses occur it affects farmers and farming practices, putting farmers in situations where they need financial support to enable them grow, expand and improve their yields. There are various micro-financing institutes in operation today in Nigeria but so many farmers still cannot access them and others encounter delayed financing. For example, seeds such as hybrid or certified seeds yield better and are more tolerant and disease resistant than others but they are sold at higher prices than the regular seeds.

According to World Bank (2022) Nigeria's economic growth improved after the pandemic-induced recession in 2020, but macroeconomic stability deteriorated. Inflation is skyrocketing, forcing millions of Nigerians, especially smallholder farmers who are mostly unnoticed, into poverty as a result of global commodity shocks, weakening currency, trade restrictions and deficit monetization. Nigeria has also been unable to benefit from rising global oil prices since 2021, as oil production has dropped to historic lows and petrol subsidies continue to eat a higher share of total oil revenues. In 2018, 40% of Nigerians (83 million people) were regarded as been poor and another 25% (53 million) were found to be vulnerable. The number of Nigerians living in extreme poverty is expected to rise by 7.7 million between 2019 and 2024, as population growth continues to exceed poverty reduction

Even though, the economy is anticipated to expand by an average of 3.2% in 2022 – 2024, adverse risks to the growth outlook include additional drops in oil production and increased insecurity. Meanwhile, continued currency shortages and reduced liquidity could have an impact on non-oil sector economic activity and jeopardize macroeconomic stability as a whole. Along with persistent budgetary and debt pressures, high inflation is also anticipated to accompany the uncertainty. While Nigeria has made some progress in socio-economic terms in recent years, its human capital development ranked 150 out of 157 countries in the World Bank’s 2020 Human Capital Index (World Bank, 2022).

Insecurity

According to World Bank report (2022) the battle against Boko Haram and other terrorist groups in the northeast, as well as ongoing occurrences of banditry and kidnappings in the north-west and parts of the southwest, has changed the security environment since 2011. The southeast is still experiencing unrest as a result of separatist agitations (unknow gunmen). In 2021, Nigeria was ranked 6th in the world terrorism index (Fig. 2 and Table 1) and 3rd in African after Somalia and Burkina Faso. In recent times, Nigeria has witnessed an unprecedented level of insecurity. This has made national security threat to be a major issue for the government (Achumba *et al*., 2013).

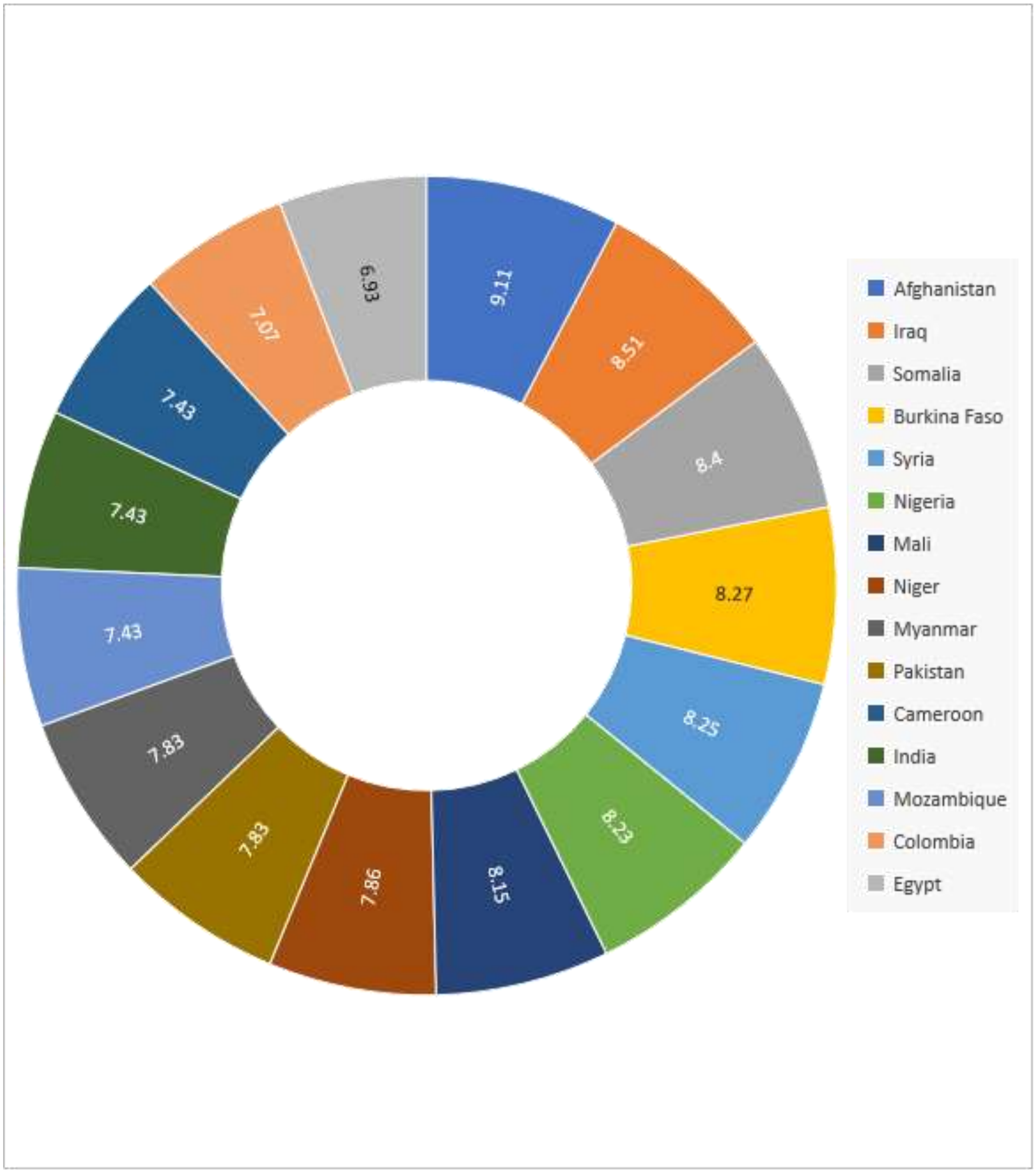
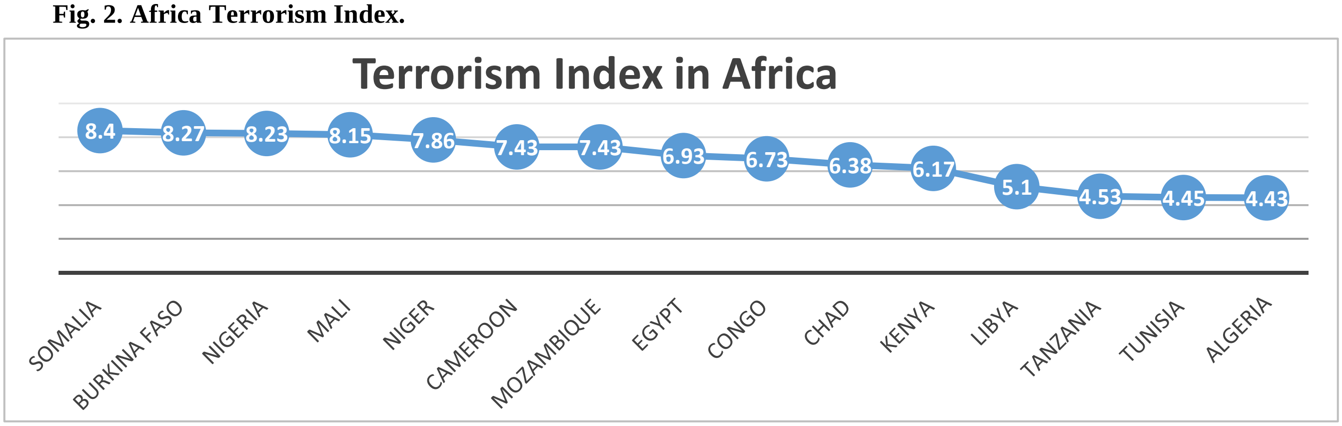


Fig. 1. World Terrorism Index.
Source: Trading Economics (2022).
Fig. 2. Africa Terrorism Index.



Source: Trading Economics (2022).

Thus, the challenges of agricultural sector in the twenty first century due to the activities of cattle herdsmen rustling and terrorist insurgence have imposed more security threats than safety to the mankind because they have created a severity of untold hardship to farmers in particular and a nation at large. According to Bolarinwa *et al*. (2012) Nigeria has recorded several violent conflicts in many rural communities from 1999 till date; conflicts that have resulted to over 10,000 deaths and internal displacement of over 300,000. These situations have resulted in distortion in farmer's livelihood since they live and earn their living from rural areas. Farmers are vulnerable to the effects of shocks from physical and social environments because they suffer huge crop and livestock losses due to insecurity challenges. Majority of those engaged in agriculture are poor and therefore, engulfed in serious financial obstacle to escape the vicious circle of poverty (Obamuyi, 2008). A lot of the farmers have resorted to the use of some adaptive measures in order to cope with shocks from insecurity.

For the last 5 years, the Boko Haram crisis has had a profound impact on northern Nigeria, specifically the North Eastern states of Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe while in the last couple of years, the following North Central states: Benue, Kaduna, Katsina and Niger, Plateau and North western states: Kebbi, Sokoto and Zamfara are ravaged. Fig. 3. shows the terrorism index calculated for Nigeria form 2011 – 2019. As the sects rampaged through these areas, communities were destroyed, millions of people (farmers) were displaced from their communities and cut short of their livelihood; insecurity spread across the region; cattle rustling increased, farm lands were abandoned, farmers or communities were taxed exorbitantly by the rampaging bandits. A land mass that is almost 15% of Nigeria has essentially become a no – go area for nomadic herdsmen and farmers.

Fig. 3. Terrorism Index in Nigeria, 2011 – 2019.

Source: Trading Economics, (2022).

The North Eastern region of Nigeria has some of the richest foraging stock in the country – and much of that is no longer available for use – because of the Boko Haram crisis. The implication has been a downward, southwards movement by nomadic Fulani herdsmen as they move in search of water and foraging resources for their cattle and this has led to intensification of resource pressures on north central and southern communities, culminating in violent clashes. Indiscriminate cattle grazing has also contributed to the destruction of vegetation and wildlife habitats, and led to the pollution of farms, rivers and waterways with cattle manure across many communities. However, Communities have experienced ecological and economic devastation as a result of this crisis. Therefore, the combination of a growing cattle population, the effects of climate change on the availability of water and forage crops, as well as the lack of access to North Eastern foraging grounds due to the Boko Haram crisis are the proximate causes of the increasing tensions between farming communities and cattle herdsmen.

Many disputes occur during dry seasons when farmers are planning to harvest crops and at the same period, the herdsmen are wandering to feed their cows on the crops. However, if crop damage occur, farmers may claim right to fight that the herdsmen should stop destroying their crops and when this happens, the herdsmen may also perceive this act as an intimidation to them. More so, conflicts could also erupt when some vegetable farmers living around riverside claim right to grow vegetables around the water side that the herdsmen should not destroy their vegetables in order to give their cattle water. There is lack of agreement in the principles of land use as the cause of the conflict between farmers and pastoralists occur (Agboola and Eniola, 1992).

In an extension to the cause of conflict between Fulani herdsmen and farmers, it appears to be no consensus among both groups as to the cause of their mutual conflicts. According to Dehaan (2002) destruction of crops by cattle and other farming properties (irrigation equipment and infrastructures) by the cattle herders themselves were the major causes of conflicts cited by the farmers. Burning of range land, blockage of the stock route and water points were another cause of conflicts reported by the cattle herders. Whatever the causes of farmers-herdsmen conflicts may be, it is evident that conflicts have been of great negative effects (loss of income/resources yield) to physical effects (such as home/farm destruction, body injury or death of family members) and socio-psychological effects like emotional exhaustion, job dissatisfaction, among others (Adisa, 2011). Banditry has posed a serious threat to farming communities in the northern parts of the country. This is because most of the farmers in agriculturally famous community of the middle belt, northwest and northeast have abandoned their farms and migrate to other communities in seeking safety for their lives hence leaving their farms fallow and unharvested crops which would pose adverse effect on the farming system.

Climate Change

A report on climate change by the USAID (2022) indicated that Nigeria has the largest economy in Africa, the most people, and a wealth of natural resources, mainly oil and natural gas. Its diverse natural zones have given rise to a diverse set of livelihoods, agricultural techniques, and commodities, all of which are vulnerable to climate change and shocks. Rising sea levels endanger southern cities like Lagos and coastal communities, making them more vulnerable to flooding and waterborne disease. Drought and decreasing rainfall, combined with rising temperatures, suffocate the country's hydropower systems and impede agricultural productivity and fisheries and aquaculture, diminishing food security and having a detrimental impact on health and nutrition. Nigeria's greenhouse gas (GHG) emissions are mostly caused by the energy sector, deforestation and land-use change.

In the report of the World Economic Forum (WEF), one of the effects of climate change is that a warmer atmosphere creates more intense precipitation events. This occurs because warmer air can hold more moisture. The amount of water vapor that the atmosphere can contain increases by about 7% for every 1.8 degrees Fahrenheit (1 degree Celsius) of increase in atmospheric temperature. Research has documented that this increase in extreme precipitation is already occurring globally and it impede agricultural activities thereby affecting food security (Table 1). The fact that the world has experienced multiple record of flooding events in recent years – including catastrophic flooding in Australia, Western Europe and China – is not a coincidence. Climate change is making record-breaking extreme precipitation more likely. Severe floods in Nigeria since September have caused the deaths of over 600 people and displaced 1.3 million from their homes, according to a government minister, in the most devastating episode of seasonal floods Nigeria has seen in a decade. Heavy rains combined with poor urban planning have made parts of Nigeria more susceptible to flooding. Around the River Niger bridge which joins Lagos to Onitsha and the rest of eastern Nigeria, sizable portions of surrounding communities have been submerged under water, crippling economic activity for many small traders and farmers (WEF, 2022).

In Anambra state, 76 people died trying to flee the flood after an escape boat capsized. More than 200,000 houses and 266,000 acres of farmland have been completely or partially damaged and yet the people were warned that more floods would still come. This has led to an increase in outbreak of water-borne diseases. The last major flood emergency experienced was between July and October in 2012, when the Niger and Benue rivers overflowed their banks. The reported death toll at the time was under 500, but it displaced a similar number of people as that of this year. But in addition to state governments failing to prepare early for seasonal floods, this year's events have also been blamed on the release of excess water from Cameroon's Lagdo dam in the middle of September. Nigeria does not have a buffer dam to prevent this flow though, this need has existed since 1982 when the Lagdo dam was completed. Some big agricultural businesses are feeling the heat and that could increase food prices in the coming months. Olam Nigeria, which produces a quarter of Nigeria's rice, says 10,000 acres of its farmland have been submerged and washed away, leading to a shortfall in harvest and this could raise prices of rice produce. "We should expect an increase in rice prices in December. Of course, that goes without saying, because the entire crop has been lost," said Ade Adefeko, the company's Vice-President for Corporate and Government Relations (WEF, 2022). The same trend was experienced in most rice growing states like, Kebbi, Nasarawa, Niger, Kogi, Kwara, Jigawa and Zamfara. The current flood has affected nearly all 36 states in the country. President Muhammadu Buhari, President of the Federal Republic of Nigeria, tweeted on October 16, 2022:

"All Federal agencies dealing with rescue and disaster management have been directed to scale up response and intervention efforts to support the victims of flooding across the country, as well as all the affected State Governments – 33 states so far affected and the FCT".

Table 1. Effects of flood on farmlands/cultivated lands coverage

Extent flood affect farmlands include:	N = 632				Total	
	AA	A	S	NA		Decision
Washing away of farmlands by flood leads to severe hunger and starvation	144 (22.8%)	247 (39.1%)	106 (16.8%)	135 (21.4%)	632 (100%)	*
Farmers in the community experience very poor harvest ofcrops after flood incidents	272 (43.0%)	163 (25.8%)	73 (11.6%)	124 (19.6%)	632 (100%)	*
Households or residents find it difficult accessing food after every flooding incident	159 (25.2%)	203 (32.1%)	117 (18.5%)	153 (24.2%)	632 (100%)	*
Growth and development of crops is affected when flood washes away farmlands	213 (33.7%)	229 (36.2%)	93 (14.7%)	97 (15.3%)	632 (100%)	*
Flood washes away the fishing nets or traps in the fishing ports/gardens	140 (22.2%)	100 (15.8%)	214 (33.9%)	178 (28.2%)	632 (100%)	#
Basic food is scarce after all flood incident	247 (39.1%)	229 (36.2%)	84 (13.3%)	72 (11.4%)	632 (100%)	*
Flood makes individuals not to gain from the crops planted in farms or gardens	166 (26.3%)	292 (46.2%)	77 (12.2%)	97 (15.3%)	632 (100%)	*
Flood brings up the issue of food insecurity and stealing of food in the community	268 (42.4%)	216 (34.2%)	83 (13.1%)	65 (10.3%)	632 (100%)	*
Flood rises the harvesting of immature crops	221 (35.0%)	172 (27.2%)	111 (17.6%)	128 (20.3%)	632 (100%)	*
Illegal trespassing into other persons farms/fishing areas increases after every flood	171 (27.1%)	213 (33.7%)	131 (20.7%)	117 (18.5%)	632 (100%)	*

- =Always while #=Sometimes

Source: Week and Wizor (2000).

Prospects

Agricultural Development and Pro-poor Interventions

The agricultural sector has been a major focus of the interventions of the Central Bank of Nigeria since the 1970s. The interventions which are driven by the development finance mission of the apex bank are motivated by the recognition of the critical role's agriculture plays in economic growth and development. These roles, according to Kinderberger *et al*. (2021) include: Supply of food to the population; Supply of raw materials for the non-agricultural sector; provision of employment; provision of investible surplus in the form of savings and taxes; and also, foreign exchange earnings through export. Stressing the importance of agriculture to the economic growth of Nigeria and hence the need for increased investment in the sector, Odetola and Etumnu (2013) of the International Food Policy Research Institute (IFPRI), Nigeria, said: "In Nigeria, because 70% of the population is employed in the agriculture sector, economic growth will be almost impossible to achieve without developing the sector.

a. **Agricultural Credit Guarantee Scheme Fund (ACGSF):** The interventions of the CBN in the agricultural sector started in 1977 with the introduction of the Agricultural Credit Guarantee Scheme Fund (ACGSF). The Fund was designed to encourage banks to lend to farmers. Under the scheme, the CBN through the Fund, guarantees loans to farmers up to 75% of the amount in default net of any security realized. According to data from the CBN, the ACGSF since inception till March 2021, has facilitated 1.180 million loans valued N122.632 billion to farmers across the country (CBN, 2022).

b. **Agricultural Credit Support Scheme (ACSS):** Another intervention of the CBN in the agricultural sector is the Agricultural Credit Support Scheme (ACSS). ACSS was introduced to enable farmers to exploit the untapped potentials of Nigeria's agricultural sector, reduce inflation, lower the cost of agricultural production (i.e., food items), generate surplus for export, increase Nigeria's foreign earnings as well as diversify its revenue base. ACSS funds are disbursed to farmers and agro-allied entrepreneurs at a single-digit interest rate of 8.0 percent. At the commencement of the project support, banks will grant loans to qualified applicants at 14.0 per cent interest rate. Applicants who pay back their facilities on schedule are to enjoy a rebate of 6.0 per cent, thus reducing the effective rate of interest to be paid by farmers to 8.0 per cent (CBN, 2022).

c. **Commercial Agriculture Credit Scheme (CACS):** In a bid to encourage commercial farming on a large scale, the CBN in collaboration with the Federal Ministry of Agriculture and Water Resources (FMA&WR) in 2009 established the Commercial Agriculture Credit Scheme (CACS) to provide finance for the country's agricultural value chain namely production, processing, storage and marketing. The CBN explained that increased production arising from the intervention would moderate inflationary pressures and assist it to achieve its goal of price stability in the country. Under the CACS, loans are provided to commercial farmers at a maximum interest rate of 9 percent.

   The scheme also allows for moratorium in the loan repayment schedule taking into consideration, the gestation period of the enterprise. Data for the CBN shows as at January 2021, banks under the CACS have disbursed N672.9 billion loans to fund 636 commercial farming projects while total loan repayment stood at N443.9 billion (65.96% repayment). In terms of employment, the CBN disclosed that the firms that benefited from the CACS recorded net job increases of 24,457 between 2009 and 2018 (CBN, 2022).

d. **Anchor Borrower Programme (ABP):** Following the sharp decline in crude oil prices in 2014 and the resultant decline in foreign exchange earnings and reserves, the CBN took radical measures to address the huge food import bill as a means of preserving the nation's external reserves. Thus, in addition to the foreign exchange restrictions placed on 41 items (which were mostly food items), the CBN introduced another intervention in the agricultural sector to boost local food production. Thus, the birth of the Anchor Borrowers Programme (ABP) which was launched by President Mohammadu Buhari in 2015. According to the CBN, the ABP is intended to create a linkage between anchor companies involved in the processing and small holder farmers (SHFs) of the required key agricultural commodities. The programme thrust of the ABP is provision of farm inputs in kind and cash (for farm labour) to small holder farmers to boost production of these commodities, stabilize inputs supply to agro processors and address the country's negative balance of payments on food. At harvest, the SHF supplies his/her produce to the Agro-processor (Anchor) who pays the cash equivalent to the farmer's account.

e. **FGN/IFAD LIFE-ND:** The Livelihood Improvement Family Enterprises Project for the Niger Delta (LIFE-ND) is a project of the Federal Government of Nigeria (FGN) designed in collaboration with International Fund for Agricultural Development (IFAD) and Niger Delta Development Commission (NDDC). The project is in response to the limited readily available options for the "disadvantaged" (youth and women) in the rural and suburban communities to improve their means of livelihood and help them to live decent lives. LIFE-ND promotes community-based on-farm and off-farm business activities along key agricultural value chain as a mechanism for job and wealth creation amongst unemployed and underemployed youths and women-headed households. The LIFE-ND Project adopts an Incubator model at the community level of the Local Government Areas, targeting core commodities of comparative advantage in such communities. LIFE-ND community beneficiaries are identified, trained and supported in different segments of Agriculture along the entire value chain. This support includes access to affordable agricultural inputs for sustainable production, agro-processing & packaging, transportation and link to competitive financing and markets. Through the LIFE Project, a robust production to marketing system that reduces food wastage and increase farm earnings for rural families is ensured. According to LIFE-ND (2022). The targeting strategies includes the following:

- promotion of enterprises responsive to women's livelihoods such as production, processing and marketing of vegetables, fish, poultry, and honey, for income, household food security and nutrition;
- time, venue and environment friendly events for women's participation;
- self-targeting of women's only groups;
- provision of at least 50 percent of leadership positions for women in commodity associations, and 30 percent of women in the project management team;
- promotion of the use of Gender Action Learning System (GALS).

f. FGN/IFAD-assisted Value Chain Development Programme (VCDP): The FGN/IFAD-assisted Value-Chain Development Programme (VCDP) seeks to enhance the productivity and profitability of smallholder farmers and small/medium-scale agro-processors by improving their access to markets, and capacity to increase yield as well as add value to locally produced raw materials through improved processing and packaging. The coverage of its implementation, which started in March 2015 across six States - Anambra, Benue, Ebonyi, Niger, Ogun and Taraba, was raised to nine (9) in 2019, by including three new States of Enugu, Nasarawa and Kogi, covering five (5) LGAs in each, while the original five (5) LGAs in each of the earlier six States were increased to eight. The Programme Development Objective (PDO) is to sustainably increase the incomes and enhance food security for an estimated 100,000 rural poor households engaged in production, processing and marketing of rice and cassava in the targeted 63 LGAs across the nine (9) States.

1. **Success Stories from Beneficiaries of Agricultural Interventions – the Case of IFAD-VCDP**

The Nasarawa state IFAD-VCDP's Knowledge Management and Communication (KMC) unit shared some success stories from program beneficiaries, including the following:

i. **Woman made 2.5 million Naira- Thanks to intervention and adoption of good agronomic practices.**

Mrs. Dinatu Ishaya of Alagye community in Doma LGA is profoundly an example to all women that every success is possible for women if only they take agriculture as serious as expected. In just a single year, she made a whooping sum of ₦2.5 million from her 3 hectares farmland where she harvested 100 bags of rice (100 kg sized bag) and sold each for 25,000 Naira. The 50-year-old mother of 8 who is the Treasurer of Salama Okolo Multipurpose Society, Alagye, Doma LGA registered as a beneficiary of VCDP in 2020 and enjoyed interventions including inputs such as seeds, fertilizer, herbicides, as well as series of trainings on best agronomic practices, business management, gender, etc.

After a careful adoption of good agronomic practices, she harvested a record 100 bags, according to her in the same place where she used to harvest an average of 55 bags. "I was so surprised when we harvested it because I was not expecting the gap to be so much like that." So, what did Mrs. Dinatu do with the money? According to her, "I used about ₦1.5 million to build a house at Ube in Akwanga LGA. I also used ₦200,000 to buy a motorcycle (Bajaj) to assist me in going to farm always. Then I spent about ₦600,000 on the education of my children while about ₦400,000 was reinvested in my rice farm (Nasarawa IFAD-VCDP, 2022).

ii. **From Grass to Grace: The Amazing Story of ₦25 Million Worth All-Female Cassava Group in Wamba, Nasarawa State.**

Michelle Obama was proved right by the United Sisters Multipurpose Cooperative Society, Wamba, Nasarawa State when she said "there is no limit to what we, as women can accomplish." All they needed was a helping hand and they got this helping hand from FGN/IFAD–Value Chain Development Programme (VCDP), Nasarawa State. The VCDP donated market stores and stalls to these women which provided a massive boost to their activities in many ways. According to Mrs. Rachael Kpemishi Samuel, the group's secretary, "Before now, we used to hawk cassava round Wamba market every market day which was very stressful and less profiting. But now, we have our modern market stalls located at the heart of the market where people come to buy cassava from us without us having to suffer. Apart from that, during rainy season, we usually lose a lot because rain usually wet our cassava flour. But today, we don't mind if the rain continues to fall every market day because we are very safe".

Apart from boosting sales and easing storage difficulties, the market stores and stalls provide additional source of income to the group. Out of 12 stores, the group retained 2 and rented out 10 at the rate of ₦25,000 per year. This means a total of ₦250,000 for all 10 market stores per year. Similarly, 10 out of 14 market stalls were rented out at the rate of ₦10,000 each per year which means a total of ₦100,000 per year. By implication, United Sisters benefit an additional ₦350,000 annual income from market stores and stalls rented out to other business owners.

iii. **We made over 5 million Naira through VCDP's Dry Season Intervention – Ozanawa MPCS**

Formed in 2002, the Ozanawa Multipurpose Cooperative Society in Doma LGA of Nasarawa State which comprises of men, women and youths have been surviving on monthly contributions from members to invest and generate profits for the betterment of the lives of every member. "When we met FGN/IFAD – Value Chain Development Programme (VCDP) in 2020, our story started changing almost immediately. The coming of VCDP was indeed the beginning of our turn around" says the Chairman, Chief Ongburu Ari Ogiri.

The Ozanawa Multipurpose Cooperative Society is one of the nine FOs that benefitted from the dry season intervention of VCDP and for the first time in their history ventured into dry season rice farming. "We cultivated 5 hectares" says the Chairman, Chief Ongburu "and achieved 5.4 metric tons per hectare. At the end of the harvest, we got 202 bags of paddy rice (120 kg per bag)." He narrated further that the entire members of the group were overwhelmed by the massive result achieved within a very short period and how they have grown in less than one year encounter with VCDP. "We concluded that VCDP is that messiah we have been waiting for. Our group has become a talk of the whole town. Since we started in 2002, we have never seen anything close to this. VCDP is so wonderful and we are grateful to them."

2. **Climate Smart Agriculture and Good Agricultural Practices (GAP)**

According to World Bank (2022), Climate-smart agriculture (CSA) is an integrated approach to managing landscapes—cropland, livestock, forests and fisheries—that addresses the interlinked challenges of food security and accelerating climate change (ACC). Good Agricultural Practices (GAP) are voluntary audits that verify that fruits and vegetables are produced, packed, handled, and stored to minimize risks of microbial food safety hazards. CSA/GAP aims to simultaneously achieve three outcomes – a triple win:

a. **Increased productivity:** Produce more and better food to improve nutrition, security and boost incomes, especially of 75 percent of the world's poor who live in rural areas and mainly rely on agriculture for their livelihoods.

b. **Enhanced resilience:** Reduce vulnerability to drought, pests, diseases and other climate-related risks and shocks; and improve capacity to adapt and grow in the face of longer-term stresses like shortened seasons and erratic weather patterns.

c. **Reduced emissions:** Pursue lower emissions for each calorie or kilo of food produced, avoid deforestation from agriculture and identify ways to absorb carbon out of the atmosphere.

Climate-smart Agriculture involved practices, such as the locally practiced conservation in agriculture, aimed at conserving soil moisture, retaining crop residues for soil fertility, disturbing the soil as minimally as possible and diversifying through rotation or intercropping; while Good Agricultural Practice (GAP) is a certification system for agriculture, specifying procedures (and attendant documentation) that must be implemented to create food for consumers or further processing that is safe and wholesome, using sustainable methods.

3. **Escaping the Death Throat through Agricultural Insurance**

The need for a specialized Agricultural Insurance Company to provide insurance cover to farmers was informed by Government's concern over the vacuum created due to the unwillingness of conventional Insurers to accept Agricultural risks, which they considered too risky. This led to the establishment of the Nigerian Agricultural Insurance Scheme on 15th of November 1987. The implementation of the Scheme was initially vested in the Nigerian Agricultural Insurance Company Limited, which was later incorporated in June, 1988 but later turned into a corporation in 1993 by the enabling Act 37 of 1993. Nigerian Agricultural Insurance Corporation (NAIC) is therefore, a wholly-owned Federal Government of Nigeria insurance company set up specifically to provide Agricultural risks insurance cover to Nigerian farmers (NAIC, 1993). According to Industrial and General Insurance Plc. (IGI, 2022) an agricultural Insurance is a policy which involves the insured (farmer) paying a little sum (premium), usually in percentage to an insurance company (insurer) to guarantee against loss due to any of the perils of **death**, **flood**, **drought** etc.

The Agricultural policy covers the followings and protects the farmers from:

- ✓ Loss of and damage to the crops due to fire
- ✓ Flood
- ✓ Drought
- ✓ Windstorm
- ✓ Lightening
- ✓ Pests and Diseases.
- ✓ Death of Livestock/Birds/Fish due to accident or diseases.

According to Imah of Agrodomain Blog (2020) there are enormous benefits for farmers who take insurance policies to protect their crops, livestock, farming and harvesting practices from setbacks. From natural disaster to the risk involved in Agro business, to disruptions arising from Agric. technologies, benefits abound in Agricultural insurance. Timely insurance pay-outs after crop losses can help small holders' smooth consumption and prevent the sale of assets. Insurance can also be a catalyst, as lenders will be more likely to extend credit to farmers covered by insurance, allowing them to make productivity-enhancing investments."

A good agricultural practice ensures investment in new technology, machines, tools and applications. When

Agricultural insurance is taken against crops and livestock, this allows farm operators to open up for new technologies in the market. New technologies (GAP/Precision Agriculture) are invented each year to help farmers get more produce from their investments. Insurance companies allow farmers to get insurance covers for the new technologies such that, if they fail, farmers will not incur losses, as the insurance company would pay them their claims.

CONCLUSION

The economic situation, instability and effect of climate change has affected a lot of professions with farming inclusive. These effects sometimes seem discouraging to farmers and farming activities and yet the farmers are persistent and strive towards improving productivity. However, there is need for implementation of Government policies, suitable or favourable to farming system, financial assistance (funding/loans/grants), accessibility of improved inputs (seeds, fertilizers, pesticides etc.), equipment and modern facilities etc. to enable efficient and effective productivity in the farming sector.

Banditry or terrorism, as of today particularly in the country has negatively impacted food security. The implication of the impact means that there is reduction in the number of farmers due to their killings and also aggravating fear in the heart of farmers and also increasing the impoverishment of farmers due to kidnappings. Thus, Farmers are not willing to go to their farmlands as they will be chased out or killed; cattle rearing has become difficult, there is reduction in the quantity of crops stored in grain silos, there are risks of attacks when farmers visit local weekly markets and many farmers have become dependent on food provided either at internally displaced persons (IDP) camps or at the houses of friends and relatives. The negative impacts have also completely affected the farming schedules of both rainfed and irrigation farming in the states. The Federal, State and Local Governments have made efforts towards tackling the banditry/terrorism, but the situation still persists with reports that bandits are now imposing taxes on some farmers in some LGAs to allow them to cultivate their crops. Harsh weather leading to environmental degradation, drought, flood or pest and diseases can be devastating financially for agricultural producers (farmers) and have substantial adverse economic impacts on agribusinesses.

However, some solutions proffered to these negative effects of climate change on agricultural production should include: alliance to several government Agricultural Development and Pro-poor Interventions, adoption of Climate Smart Agriculture and Good Agricultural Practices (GAP), adequate preparation of farmers towards the upcoming season, adequate and accurate weather forecast, increase in availability of veterinary doctors, legislation of pesticide distribution and use, agricultural funding for research and technology development, Trade Liberalization and Market Development, Funding and infrastructure development and Consistency in government policy. Hitherto, our farmers are celebrated today due to their resilience and thrive against all odds and obstacles faced in the present-day farming, contributing immensely in terms of food security. The Agricultural sector will and still contributes to the Nation Gross Domestic Product (GDP) all as a result of farmers' efforts and persistence. As it said, "*Though the struggle exists but they the farmers keep pushing and making a difference*".

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ASSESSMENT OF CLIMATE-SMART AGRICULTURAL PRACTICES AND FOOD SECURITY SITUATION AMONG FARMING HOUSEHOLDS IN SOUTHERN AGRICULTURAL ZONE OF NASARAWA STATE, NIGERIA

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ABSTRACT
Food security in Nigeria faces climate change risk with likely devastating outcomes on food production capacity. The study Assessed 'Climate-Smart Agricultural Practices and Food Security Situation among Farming Households in Southern Agricultural Zone of Nasarawa State, Nigeria'. A multistage sampling approach was used to select the farming households. Primary data were collected using a designed questionnaire. Data were analyzed using principal component analysis (PCA), household dietary diversity score (HDDS) and descriptive statistics. Under PCA, climate-smart agricultural practices have been grouped into 5 components: comprehensive field management (40.5%); on-farm risk reduction (15.3%); crop/livestock or mixed management (12.2%); agro-forestry (8.1%) and soil conservation practices (19.8%). Farming households with a confirmed average HDDS (2.7) were considered food insecure and the group with low dietary diversity score (75.7%) provides the percentage of food insecure households. Absence of information (33.6%) and capital (26.6%) were main factors constraining the use of climate-smart agricultural practices (CSAPs). It was revealed that CSAPs has the potential to improve food security. The research recommends encouraging farming households to adopt as many CSAPs as possible to improve their food security situation. Since absence of information is a key constraint, capacity building of extension agents to help design and formulate extension messages and agricultural policies that can hasten the spread of CSAPs is needed.
Keywords: *Climate-smart agricultural practices, farming households, food security.*

INTRODUCTION
Food security in Nigeria faces climate change risk with likely devastating outcomes on food production capacity. Increased temperatures and frequent variation in rainfall patterns have reduced yields, promoted the development of weed and pest infestation, and increased the probability of short-term crop failures and long-term productivity losses (World Bank, 2010). Efforts to improve global food security are most needed as the demand for food is increasing due to a rapid population growth.

Understanding the exact impact of climate change on food security is complex because vulnerabilities are unevenly distributed around the world, it ultimately hinges on the ability of communities and countries to address risks. In the context of food security, while some parts of the world may benefit from climate change, developing countries (such as Nigeria) may be negatively affected. Global warming and climate change have many negative consequences on agriculture, and all these consequences will increase as global temperature increases (Ayo *et al*., 2010).

According to Food and Agriculture Organization (2014), there will be a considerable crop yield loss that will be caused by climate change which will negatively affect farming households' livelihoods in Nigeria. As a result, the food security and income-generation opportunities of the farming households dependent on agriculture may be threatened. African crop yields estimated to decline by 10-20% by 2050 could even be up to 50% due to climate change (Nwaobiala and Nottidge, 2013). Given the severe food insecurity around the world, it was important to take measures to mitigate the negative outcomes of climate change on farm production. In response, the notion of climate-smart agricultural practices was created when the adoption of the Paris Agreement was introduced to strengthen global reaction to the threat of climate change by sustaining global temperature increase. (UNFCCC, 2015).

Climate-smart agriculture is not a new set of practices given the need to collectively discourse food security and climate change, it is a means to introduce the necessary changes in agricultural systems (FAO, 2013). Climate-smart agricultural practices share sustainability principles and guiding principles for food security, it emphasizes on production, farming households, increasing productivity, incomes and ensuring their stability. This package also focuses on four measurements of food security in times of accessibility, availability, usage and durability. Climate-smart agriculture measures include substantiated approaches such as use of mulch, intercropping, and incorporated pest innovations such as disease management, reduced/minimum/zero soil tillage, use of legumes in crop rotation, planting of trees on arable land/planting of crops on forest land, mixed farming, aquaculture, irrigation, detailed weather forecasting for farming households and timely notification strategies (FAO, 2010; World Bank, 2011). Furthermore, it includes adopting recent technologies such as modifying crop genetics to assist farming households cope with climate uncertainties and prepare the environment. Additionally, climate-smart agriculture has an interest in post-harvest management of agricultural outputs along the value chain to reduce losses and enable sustainable consumption patterns. Without climate-smart agriculture, surrounding areas could become uncultivable due to land degeneration through desertification, soil corrosion, continuous-cultivation and over grazing (World Bank, 2012). However, it stands that a commitment to climate-smart agriculture is needed by focusing on farming households in developing countries like Nigeria, the key to transforming the entire agricultural system. The objectives of the study include; identifying the climate-smart agricultural practices used, measuring the food security situation of the farming households and identifying the constraints to the use of climate-smart agricultural practices in the Southern Agricultural Zone of Nasarawa State, Nigeria.

METHODOLOGY

The study was carried out in Southern Agricultural Zone of Nasarawa State, Nigeria. The region is known for its long rainy season (May to October). The usual annual rainfall is about 839mm and the average annual temperature is 28.4°C. Products cultivated in the study area include; roots and tuber crops, grains, legumes, cocoyam. Furthermore, farming households in the study area put up domestic animals comprising: cattle, poultry, goats and sheep. Durable tree crops grown by farmers involve citrus, mangoes and cashews (NADP, 2017). Majority of the population are farmers.

A multi-stage sampling approach was employed to select respondents. During this stage, 3 Local Government Areas (LGAs) were randomly chosen from the 5 LGAs in the study area. Second, the three communities were purposively selected from each of the three LGAs, resulting in a total of nine (9) communities. Finally, due to the large population of farmers, 14% of the farmers were randomly selected from each of the nine communities giving an aggregate of 222 farming households sampled for the study.

Primary data were obtained using questionnaire. The questionnaire was administered with the help of trained enumerators. The data includes a collection of different climate-smart agricultural practices (CSAPs) farming households employ in response to climate change. This includes use of better varieties of crop, use of legumes in crop rotation, effective use of nitrogenous fertilizers, modification in dates of planting, planting trees on arable fields, use of terraces, use of living obstacles, use of cover crops, irrigation, etc., and the challenges associated with use of these practices. The questionnaire also provided a daily food intake schedule for respondents to complete.

Principal component analysis (PCA), household dietary diversity scores (HDDS) and descriptive statistics were utilized to analyze the data. The PCA criterion is exemplified as following:

$$Y_1 = a_{11}x_{12} + a_{12}x_2 + \dots\dots a_{1n}X_n$$
$$\cdot \qquad \cdot \qquad \cdot \qquad (1)$$
$$Y_j = a_{j1}x_{j2} + a_{j2}x_2 + \dots\dots, a_{jn}x_n$$

Where;

$Y_1 \dots Y_j$ = are unrelated principal components

$a_1 \dots a_n$ = correlation coefficients

$X_1 \dots X_j$, = specific strategic choices influenced by specific factors.

HDDS are obtained by adding the number of food group utilized by the farming household during the 24-hour recollection moment, from a maximum of 12 per day. This is illustrated below:

$$\text{Average} = \frac{\sum_{i=1}^{n} \text{HDDS}}{N}$$

where n= 1, 2, . . ., 12 per day

N= total number of farming households

RESULTS AND DISCUSSION

Climate-smart agricultural practices used by the farming households:

The principal component analysis made it feasible to reduce the largeness of the data without missing much communication. As indicated in Table 1, 16 climate-friendly farming practices are actively used by farming households in the study area. Using principal component analysis (PCA) the constructs were rotated using varimax technique (Chatterje *et al*., 2015), related practices were grouped into five (5) major components. This was then used for further analysis.

Table 1, illustrates the descriptive statistics of each individual components (climate-smart agricultural practices). The most generally employed component was that of comprehensive field management practices. 42% of farming households use at least 1 element of this component. This component includes use of cover crops, use of better varieties of crops, use of legumes in crop rotation, modification in times of planting, bound ridge system, diversifying varieties of livestock and crop, irrigation, use of organic manures and use of mulch. The second component was on-farm risk reduction practices used by 16% of farming households. This component included the use of terraces, reduced/minimum or no tillage and adoption of living obstacles. The third component relates to crop/livestock management practices used by 13% of the farming households which includes effective utilization of nitrogenous fertilizers, and utilization of better livestock breeds and crop varieties. The fourth component, which involves agro-forestry practices used by 9% of the farming households, includes planting crops on forest lands and planting trees on arable field. The fifth and second most frequently used component was of soil conservation practices used by 20% of farming households includes reduced/minimum or no tillage and utilization of mulching.

Table 1: List of climate-smart agricultural practices:

Component	Rate of Users (%)	Elements
Comprehensive field management practices (component 1)	42	use of organic fertilizers, modification in time of planting, use of mulch, diversifying livestock breeds and crop varieties, Irrigation, Utilization of enhanced crop varieties Bound/Tied ridge system.
On-farm risk reduction (component 2)	16	Reduced/minimum or no tillage, Adoption of living obstacles, Adoption of terraces.
Crop/livestock management practice (component 3)	13	Effective utilization of nitrogenous fertilizers, Utilization of better livestock breeds and crop varieties
Agro-forestry practice (component 4)	9	Planting crops on forest land Planting trees on arable field
Soil conservation practice (component 5)	20	Reduced/minimum or no tillage Utilization of mulching.

Source: Field survey, 2021

Measurement of food security situation of farming households using household dietary diversity score (HDDS).

To better understand the food groups consumed by farming households and their food security situation, household dietary diversity score (HDDS) was estimated. According to Cordero-Ahiman *et al.* (2017), there is no particular threshold value for classifying food groups. In this study, HDDS ≤ 3 was used as benchmark for classifying the low dietary diversity group. The range of ≥ 4 was classified as the moderate dietary diversity group, while HDDS ≥ 7 was classified as high dietary diversity group. The average HDDS was 2.7 (100%) for all the farming households. This explains that the food security situation of the farming households in the studied area is on the low. The findings shown in Table 2, shows a majority (about 75.7%) of the farming households belonged to the class with low dietary diversity score. Additionally, the finding also shows that some households (21.2%) consumed 4 to 6 food groups (classified as moderate dietary diversity group) while few of the households (3.2%) consumed about 7 or more food groups (high dietary diversity group). The justification for this could be that majority of the farming households are financially constrained as they do not participate in non-agricultural activity to generate additional income and also, lack information as a key constraint on the use of climate-friendly farming practices to improve their food security situation.

Table 2: Food security situation of farming households using HDDS

Food groups	Frequency	Percentage
Grains	176	29.3
Tubers/Roots	111	18.5
Vegetables	78	13.0
Fruits	32	5.3

Meats	12	2.0
Eggs	24	4.0
Fish and other sea foods	21	3.5
Legumes and seeds	36	6.0
Milk and dairy products	52	8.7
Fats and oil	15	2.5
Sugar/honey	25	4.2
Spices, condiments and Beverages	18	3.0
Average HDDS	2.7	100
Group/Classes	**Frequency**	**Percentage**
Low dietary diversity group (consume 3 or less food group)	168	75.7
Moderate dietary diversity group (consume 4 to 6 food group)	47	21.2
High dietary diversity class (consume 7 to 12 food group)	7	3.1
Total	**222**	**100**

Source: Field survey, 2021

Constraints to the use of climate-smart agricultural practices by the farming households

An attempt was made to identify the challenges faced by farming households using climate-smart agricultural practices to achieve food security. The result shown in Table 3, indicates that there are significant factors limiting the use of climate-smart agricultural practices by farming households in the study area. Absence of information is the most limiting factor (33.6%). A contemporary study by Sapkota *et al.* (2018), discovers that farming households who received information about their farms using modern information and communication technology had higher yields. The next limiting factor was scarcity of capital (26.8%), the availability of capital will boost farming households' financial resources, increase their cash base and enable households to buy significant contribution. Arguably, where capital is available, farming households are further inclined to utilize capital-intensive climate-smart agricultural practices, particularly irrigation, use of better livestock breeds and crop varieties or planting of trees on agricultural land, and also, competently paying for labor-intensive technologies. Adekemi *et al.* (2016), presumed that capital raises farming households' ability to purchase better seeds, fertilizers and other climate-friendly farming inputs. Nonetheless, this technology goes beyond other investment options accessible to farming households. Other opposing factors include labor shortages (21.6%) and in adequate access to water (11.2%).

Table 3: Constraints to the use of climate-smart agricultural practices.

Constraints	Frequency	Percentage
Scarcity of capital	67	28.8
Absence of information	84	36.0
Labor shortages	54	23.2
Inadequate access to water	28	12.0
Total	233	100

Source: Field survey, 2021

CONCLUSION AND RECOMMENDATIONS

Climate-smart agricultural practices have a significant association with farming households' food security situation. The rate at which CSAPs were encompassed into farming activity was still low, with comprehensive field management practice being the most commonly used practice to improve agricultural productivity. The result also shows that farming households are food insecure with a low dietary diversity score. Absence of information on climate-friendly farming practice and scarcity of capital were the main obstacles to adopting CSAPs in the study area. The study recommends farming households to employ CSAPs wherever possible judiciously, in order to have a greater impact on their food security status and an elixir to mitigate the negative consequences of climate change on agricultural activities. Considering the constraints, capacity building of extension agents is necessary to assist in creating agricultural policies that can hasten the design and development of improved messages and the spread of climate-friendly farming practice.

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BENEFITS AND CONSTRAINTS ASSOCIATED WITH THE PRODUCTION OF HORTICULTURAL CROPS AMONG RURAL DWELLERS WITHIN OTUKPA, OGBADIBO LGA, BENUE STATE

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ABSTRACT

The study was conducted to examine the benefit and constraints associated with the production of horticultural crops among rural dwellers within Otukpa, Ogbadibo Local Government area of Benue state in 2023. Six communities (Efugo, Ede, Orido, Odoba,Olabigba, Olachagbaha) were surveyed. Both purposive and multistage random sampling techniques were adopted in selection of 60 farmers which made up the sample size. Primary data were collected using structured questionnaire from the sampled farmers. Data were analyzed with the use of statistical tools such as percentage, mean and four point Likert scale. The result of the study shows that majority (56.67%) of the farmers were females and 43.33% were males, majority (76.6%) were married while 100% of the farmers had one form of educational level or the other, however, secondary education was ranked highest with 50.00%. Olericulture production has the highest percentage of engagement followed by pomology, then floriculture production. It was observed from the study that majority of the respondents gained substantial income from horticultural activities (95.00%%), followed by ease in sourcing fresh food (93.33%), reduction in family budget (90.00%), better nutrition (66.67%), source of employment (33.33%), for environmental beautification (13.33%) and to ease emotional stress (5.00%). However, farmers are faced with challenges such as inadequate finance (X=3.45), lack of technical knowhow (X=3.42), pest and disease (X=3.40) and lack of storage and processing facilities (X=3.39), consequently, the study therefore recommends that the horticulturist in the study area should pool their resources together through forming cooperative society to enable them surmount some of the identified constraints to boost their production and generate more income.
Keywords: *Horticultural crops, production, benefits, constraints, percentages, four point likert scale.*

INTRODUCTION

Horticulture is one of the fastest growing sectors of agriculture. Horticulture is a section of agricultural sciences that employs scientific understanding to produce vegetables, fruits and flowers and which is meant to enrich human diet. The growth of this sector was about 5.5 % during last two and half decades. Thus, horticulture can be defined as the science, technology, and business involved in intensive cultivation of plants for human use, including fruits, vegetables and ornamental plants (Alemayehu, 2016). Based on crop grouping and use the main division or branches of horticulture are Olericulture, a branch of horticulture which include the production of vegetable, processing and marketing. Floriculture is the cultivation and management of flowers, flowering plants and foliage plants. It also includes their uses in ornamental construction and floral arrangement (ISHS, 2011). Pomology, has to deal with the production of fruits and nuts that are basically perennials. Horticultural crops are utilized by both, individuals and industries to enhance the nutritional and economic standards. It is a basic requirement for human health and well-being. Horticultural crops are the primary source of poverty reduction in most agriculture-based economies (Anríquez and Stamoulis 2007). The expansion of smallholder farming can lead to a faster rate of poverty alleviation, by raising the incomes of rural cultivators and reducing food expenditure, and thus reduces income inequality (Resnick, 2004).
Notwithstanding the critical role that horticulture plays in modern communities, horticulture globally is undergoing some very significant challenges that are impacting on both the production of horticultural crops and also on the priorities for research and development. The horticultural sub-sector also reflects the problems in the agricultural sub-sector. These problems include inadequate knowledge and technology of production, insufficient planting materials, land tenure, poor extension services and insufficient post-harvest facilities (Babatola, 2004).

In light of this the study was conducted to examine the benefit and constraints associated with the production of horticultural crops among rural dwellers within Otukpa, Ogbadibo local government area of Benue state with the specific objectives to determine the benefits derived by the respondents and also to determine the constraints encountered in horticultural production in the study area.

MATERIAL AND METHODS

The study was conducted to examine the benefit and constraints associated with the production of horticultural crops among rural dwellers within Otukpa, Ogbadibo local government area of Benue state in 2023. Six communities (Efugo, Ede, Orido, Odoba,Olabigba, Olachagbaha) were surveyed. Otukpa is located on latitude 05^0 3^l N, Longitude 07^0 23^l E and 130m above sea level and rainfall average of 2300mm/annum. Multi-stage random sampling techniques were adopted in selection of 60 respondents which made up the sample size. Primary data were collected using structured questionnaire from the sampled respondents. Data were analyzed with the use of statistical tools such as frequency, percentage and four point Likert scale model and ranking using the mean score in SPSS.

RESULTS AND DISCUSSION

Result of data analysis in Table 1 shows that majority of the respondents were females (56.67%) than males (43.33%), with mean age of 40 years, which is in agreement with the findings of Tripathi *et al.* (2015) that majority of the vegetable respondents fall within the age bracket of 30-40 years indicating that there is a bright future for vegetable farming in the study area if, the potential of these youths are properly harnessed. Also it is an indication that most of the farmers are in their productive age, hence active participation in farming activities. Majority (76.67%) were married with average household size of 10 members indicating that they are responsible individuals, also, all (100%) of the farmers had one form of educational level or the other, however, secondary education was ranked highest with 50.00% which is an indication that most of the farmers are literate and thus enlightened and are aware of the importance's of horticultural production. More so, greater number (41.67%) had spent at most 10 years in production of horticultural crops which agrees with the findings of Mohammed and Afework (2016). They farmers cultivate a mean farm size of 0.5 hectare, a similar results were obtained by Mohammed and Afework (2016) which revealed that majority of fruit and vegetable farmers cultivate between 0.1- 5 hectare.

Data analyzed for horticultural practices in the study area is presented in Table 2. The result revealed that 78.33% of them are into Olericulture (vegetable production), 20.00% are into pomology (fruits and nuts production) while only 1.67% of the respondents are into floriculture production (flowers and Ornamental production). This could be due to market demand within the study area for vegetable as source of daily livelihood. This agrees with the findings of Kamei (2013) that all kinds of horticultural crops are viable and earn an additional income to every household.

Data analyzed for the benefits derived from horticultural practices in the study area is presented in Table 3. It was observed from the table that majority of the respondents gained substantial income from horticultural activities (95.00%%), followed by ease in sourcing fresh food (93.33%), reduction in family budget (90.00%), better nutrition (66.67%), source of employment (33.33%), for environmental beautification (13.33%) and to ease emotional stress (5.00%). The result indicates that majority of the respondents depend on horticulture for sustainability of their livelihood since majority of the horticulturist derived income from the practices, thus horticultural crop production should be encouraged to alleviate the rate of poverty. This is in agreement with the findings of Suleiman et al., (2020), that majority of the respondents in their study area generate a large amount of income from engaging in horticultural activities.

Data analyzed for the constraints to horticultural crop production in the study area is presented in Table 4 which shows that inadequate finance (x=3.45), lack of technical knowhow (x=3.42) and pest and disease were outstanding among the challenges facing the production of horticultural crops. This result indicates that financial insufficiency seriously impedes horticultural crops production in the area. Again, lack of storage and processing facilities(x=3.39) and insufficient planting materials (x=3.37) were among the strong constraints identified. Also, poor produce price (x=3.20), small available land (x=3.03) were observed as high militating factors. However, inadequate labour supply (x=2.70) was not known as strong factors hindering horticultural crops production in the area. The findings agress with the findings of Babatola (2004), some of the problems hampering the development of horticultural activities in Nigeria are inadequate knowledge and technology of production, insufficient planting materials, land tenure, poor extension services and insufficient post harvest facilities which has similarity with present result obtained in this study. Thus, horticulturist in the study area should be encouraged to pool their resources together through forming cooperative society to enable them surmount some of the identified constraints to boost their production and generate more income.

Table 1: Socioeconomic Characteristics of the respondents

Socioeconomic characteristics	Frequency	Percentages
Sex		
Male	26	43.33
Female	34	56.67
Age		
≤30	15	25.00
31-40	21	35.00
41-50	20	33.33
≥50	8	13.33
Marital status		
Single	7	11.67
Married	46	76.67
Separated	3	5.00
Divorce	4	6.67
Family size		
≤10	52	86.67
11-15	8	13.33
≥16	0	0.00
Level of education		
No formal education	0.0	0.0
Primary education	24	40.00
Secondary education	30	50.00
Tertiary education	6	10.00
Years of horticultural crops production		
≤10	25	41.67
11-15	17	28.33
16-20	11	18.33
≥21	7	11.67
Farm size		
≤0.5	49	81.67
0.6-1.0	11	18.33

Source; field survey data analysis, 2023

Table 2: Type of horticultural practices in the study area

Type of horticultural activity	Frequency	Percentages (%)
Olericulture	47	78.33
Pomology	12	20.00
Floriculture	1	1.67
Total	60	100

Table 3: Benefits derived from horticultural practices in the study area

Benefit	Frequency	Percentage (%)
Reduction in family food budget	54	90.00
Better nutrition	40	66.67
Income generation	57	95.00
Ease emotional stress	3	5.00
Easy source of fresh food	56	93.33
Environmental beautification	8	13.33
Source of employment	20	33.33

Multiple Responses

Table 4: Mean scores of Constraints facing horticultural crops production

Challenges	Mean score	Decision
Inadequate finance	3.45	Accept
Small available land	3.03	Accept
Inadequate labour supply	2.70	Accept
Insufficient planting materials	3.38	Accept
Pests and diseases attack	3.40	Accept
Poor produce prices	3.20	Accept
Lack of technical know how	3.42	Accept

Lack of storage and processing facilities	3.39	Accept

Source; field data analysis, 2023, multiple responses, accept any mean ≥2.5, otherwise reject

CONCLUSION

The production of horticultural products play significant nutritional role in our everyday diet and likewise income generation to sustain livelihood, from this study it can be observed that majority of the respondents are in their working age class and majority are female. Olericulture production has the highest percentage of engagement followed by pomology, then floriculture production. Income generation, source of fresh food, reduction in family budget, better source of nutrition, source of employment and beautification of the environment are benefits derive from horticultural farming among others. However horticultural farming in the study area is faced with some problems such as inadequate finance, lack of technical knowhow, pests and diseases and lack of storage and processing facilities are the major constraints affecting horticultural farming in the study area. Also, insufficient planting materials, poor produce price, small available land for cultivation and inadequate labour supply. The study therefore recommends that the horticulturist in the study area should pool their resources together through forming cooperative society to enable them surmount some of the identified constraints to boost their production and generate more income.

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ANALYSIS OF AGRICULTURAL EXTENSION SERVICES DELIVERY AMONG SMALLHOLDER GROUNDNUT FARMING HOUSEHOLDS IN RANO LOCAL GOVERNMENT AREA OF KANO STATE, NIGERIA

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ABSTRACT
This study analyzed agricultural extension services delivered and used among smallholder groundnut farming households in Rano local government area of Kano state, Nigeria. Purposive sampling procedure was used in selecting 2 communities based on their popularity in groundnut farming and a total of 81 respondents were randomly selected for the study. Data were collected with the aid of structured questionnaire. Descriptive statistics (frequency, percentage, mean and standard deviation) and regression analysis were used in analyzing the data. The results revealed the mean age of the respondents to be 37.7years, 100% of the respondents were male, with only 11.1% having no formal education and 88.9% engaged in other sources of income besides farming activities. Most (59.3%) respondents received information on groundnut farming activities very frequently from extension agents. Household size, educational level and contact with extension agents significantly influenced access and used of extension services. High cost of inputs, labor and GSM services were identified by 58%, 53.1% and 53.1% of the respondents respectively as constraints to information access and utilization. It was concluded that agricultural extension services on groundnut production were accessed and utilized by farmers as delivered by the service providers which was influenced by some socio-economic characteristics. However, it was recommended that training on record keeping should be strengthen by extension services providers to ensure adequate production data record by the farmers.
Keywords: *Extension services, Smallholder, Groundnut, Households*

INTRODUCTION
Groundnut *(Arachis hypogaea* L.*)* is the 6th most important oil seed crop in the world. It contains 48- 50% oil, 26-28% protein and 11-27 % carbohydrate, minerals and vitamin (Mukhtar, 2009). According to FAOSTAT (2011) and Girei *et al*. (2013), groundnut is grown in nearly 100 countries in the world with China, India, U.S.A, Indonesia, Nigeria, Myanmar and Sudan as major producers. A report by FAO in 2014 revealed that groundnut on an average is grown on 26.4 million hectares worldwide with a total production of 41.3 million metric tons and productivity of 1.676 kg ha^{-1} during 2012 (FAO, 2014). Moreover, Nigeria is one of the world's largest groundnut producers, accounting for 10%, 39% and 51% of the total worlds, Africa's and West Africa's groundnut production, respectively (ICRISAT, 2011). Before the fossil oil boom, groundnut was one of the major sources of revenue accounting for about 70% of total Nigeria's export earnings, making it the country's most valuable single export crop ahead of other cash crops like cotton, oil palm, cocoa and rubber (Harkness *et al.*, 1976). However, in the post-1967 period, the combined effects of drought, increasing prevalence of diseases such as rust, leaf spots and groundnut rosette disease (GRD) in addition to lack of crucial information on improved agricultural practices have caused a decline in groundnut production (ICS-Nigeria, 2005). This is exacerbated by the dearth of agricultural extension workers and the rate at which available research results were transferred to farmers due to limited resources available to the public extension agencies with which farmers are reached free of charge in developing countries (Budak *et al*., 2010). However, with the huge potential of this cash crop and in view of the above-mentioned problems, the findings from the study will serve as guide to government, development partners and researchers for improvement in groundnut production and bridging the gap of knowledge. In view of therefore, this study has been designed with the following objectives: identify the extension services accessed and utilized by groundnut farming households and sources of information used in accessing the extension services delivery; examine the relationship between socio-economic characteristics of respondents and their sources of information; and assessed the constraints militating against accessing extension services delivery in the area.

METHODOLOGY

The study was carried out in Rano Local Government Area (LGA) of Kano State. Kano State is located in North-Western Nigeria. The State is situated in a semi-arid region which lies between latitudes $10^{0}30'$ and $13^{0}02'$ north of the equator and longitude $7^{0}40'$ and $10^{0}39'$ east of the Greenwich meridian. It has a projected population of 10,067,208 people with an almost equal distribution of males (51%) and females (49%) (NPC, 2006) Agriculture is the mainstay of the economy involving at least 75% of the rural population. It is the major producer of groundnut before the oil boom of 1970s (producing at least 50% of the country total output).

Sampling Techniques

The communities, associations and respondents considered in the study were purposively selected due to implementation and participation in Tropical Legume 3 (TL3) Project in the area.

Table1: Sample Size

s/n	Community	Name of Associations	Total number of farmers	Sample size (100%)
1	Rano	1. Kofar kudu groundnut farmers association Rano	26	26
2	Rurum	1. Bayan kargo groundnut farmers association Rurum	26	26
		2. Bakin kasuwa multipurpose farmers association rurum	26	26
	Total		**81**	**81**

Source: KNARDA, 2021.

Data Collection Procedure and Analytical Tools

Data was collected using structured questionnaire, while descriptive and inferential (linear regression) statistics were used to analyze the data. The model of the linear regression was specified below:

$Y= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + ei$……………………………. (1)

Where;

Y=Information source (number)

X_1= Age (years)

X_2= Gender (Female = 1, Male = 0)

X_3= Household size (numbers)

X_4= Years of farming experience (years)

X_5= Other sources of income

X_6= Extension contacts

X_7= Education level

β_1 - β_7 = Regression Coefficient

β_0= Intercept

RESULTS AND DISCUSSION

Socio-economic Characteristics of Groundnut Farmers

The results from table 2 shows case the minimum age of respondents to be 18 and maximum of 65. The mean age was 37.7 years. This implies that majority of the respondents are in their active age of life and farming requires adequate attention and a lot of sense of responsibilities. Their active age showcases the tendency and ability to access and utilize the necessary services that will improve their production activities. The mean of the household size was found to be 8 with minimum and maximum household size of 1 and 30 respectively. This implies that the respondents used the size of the household in obtaining necessary extension services. The average years spent in groundnut farming was found to be 14.4 with minimum and maximum years of 3 and 42, respectively. The years spent in groundnut production determined the experience obtained in the activity which resulted in seeking for necessary advices and information and adoption of improved technologies for improvement in the production processes that may lead to better output and improvement in livelihood.

The result from Table 3 shows that the entire groundnut farmers considered in the study were male implying that male dominated the production of groundnut in the area or else took advantage of the project without considering their female counter part. The male dominancy may be attributed to culture in Hausa communities where most farming activities were carried out my male which resulted in dominating the farming activities itself. In addition, it was found that most of the respondents (72.6 %) were married. This may lead to increase in their household size which invariably reduce cost of production if they employ family labor on their farms. The result further shows that most of the farmers had one level of formal education which may assist them making a wise decision to accesses and utilize extension services provided to them by the services providers. With respect to extension contact leading to access and utilization of services provided shows that most (88.9%) of the farmers had contact in one way or the other with extension personnel. This may be attributed to their belonging of cooperative group as most extension agents prefers reaching farmers in group rather than individual. This led to accessing required services that may lead to improvement of their farming activities. Most (88.9%) of the farmers have other source of income besides farming. This contributes to the sustainability of the farming activities and also help in sustaining the livelihood of the households.

Sources of Information on Groundnut Production

Table 2: Socio-economic characteristics of groundnut farmers

Variables	Minimum	Maximum	Mean
Age (years)	18	65	37.7
Household size	01	30	8
Farming experience (years)	03	42	14.4

Table 3: Socio-economic characteristics of groundnut farmers

Variables	**Frequency**	**Percentage**
Marital status		
Married	59	72.6
Single	21	25.9
Divorced	1	1.2
Total	81	100
Educational level		
No formal education	14	17.3
Primary education	15	18.5
Secondary education	38	46.9
Tertiary	14	17.3
Total	81	100
Extension contacts		
Having contact	72	88.9
No contact	9	11.1
Total	81	100
Other sources of income		
None	9	11.1
Brick layering	11	13.6
Civil service	6	7.4
Driving	3	3.7
Electrician	1	1.2
Fishing	2	2.5
Tailoring	12	14.8
Trading	37	45.7
Total	81	100

Source field survey, 2022

The results in table 4 depict the sources of extension services rendered by service providers with most of the services accessed from extension agents. This is attributed to the fact that the respondents participated in the project and the project ensured farmers worked in group for easy contact, accessing the necessary services required for the smooth running of the project. This is to ensure farmers adhered to the good agronomic practices that will help in attaining the expected maximum yield at the end of harvest.

Relationship between socio-economic characteristics of the farmers and sources of information used.

The findings in table 5 revealed that household size, education level and extension contact had significant relationship with sources of information on extension services rendered by services providers. The household size was negatively (B= -.363) significant at ($p<0.01$) explained the outcome. This indicated that as the household size decrease the more sources of information used. Similarly, education level was positively (B= 1.592) significant at ($p<0.01$) meaning that the higher the education level the more the sources of information used. Furthermore, extension contact was also negatively (B= -.363) significant at ($p<0.01$) meaning that the less contact with extension agents the more sources of information used for them to be able to acquire the necessary information.

Table 4: Sources of information on groundnut production

Information source	**Very frequent F (%)**	**Frequent F (%)**	**Rarely F (%)**	**Very rarely F (%)**	**Not at all F (%)**
Extension agent	48(59.3)	22(33.3)	11(18.5)	-	-
Friends/relatives	43(53.1)	23(28.4)	7(8.6)	4(4.9)	4(4.9)

Radio	6(7.4)	19(23.5)	30(37)	17(21)	9(11.1)
Newspaper	-	2(2.5)	27(33.3)	17(21)	35(43.2)
Agricultural show	3(3.7)	7(8.6)	32(39.5)	22(27.2)	17(21)
Bulletin/handbill	3(3.5)	2(2.5)	19(23.5)	22(27.2)	35(43.2)
NGOs	2(2.5)	5(6.2)	22(27.2)	22(27.2)	29(35.8)
Research institute/universities	17(21)	5(6.2)	11(13.6)	23(28.4)	25(30.9)
1nternet	1(1.2)	4(4.9)	6(7.4)	14(17.3)	56(69.1)

Field survey, 2021

Table: 5 Relationship between socio-economic characteristics of groundnut farmers and sources of information used.

Variables	B	Std. Error	T	Sig.
(Constant)	29.878	3.359	8.894	.000
Age (years)	-.072	.101	-.713	.478
Household size_(number)	-.363	.138	-2.632	.010***
Education level	1.592	.487	3.271	.002***
farming experience	.084	.091	.925	.358
Other income source	-.099	.179	-.553	.582
Marital	.398	1.221	.325	.746
Extension contacts	-3.992	1.513	-2.639	.010***
R^2	.504			
F Value	10.592			

Source: Field survey, 2021.

Extension Services Accessed and Used

The findings in Table 6 shows the distribution of the extension services received and used by the farmers. Most of the farmers had access to and used the entire extension services provided on groundnut production. This resulted in more output that will also improve the livelihood of the farmers. Record keeping 23.4% (n=19) was the least extension service received by the farmers and Poor record keeping resulted in in appropriate data on their production.

Constraints to Information Access and Used

The results in table 7shows the problems militating against accessing and utilization of information on groundnut production through extension service delivery in the study area. The major constraints were cost of inputs such as seed and fertilizer (58%), followed by cost of labor (53.1%) and those accessing information using ICTs such as internets (53.1%) also found it difficult. Lack of adequate technical knowledge about the recommended farm practices and language barrier was also identified as factors militating against farmer`s access and utilization to information delivered to them. This may hinder the attainment of maximum yield per hectare not necessarily on the project but also beyond.

Table 6: Extension services accessed and used

Extension services	Frequencies	Percentage
Soil and climatic requirement	78	96.3
Site selection and land preparation	80	98.7
Sowing and sowing date	76	95.0
Weeding	67	82.7
Fertilizer requirement	54	66.7
Credit facilities	57	70.4
Market information	43	53.1
Harvesting	48	59.3
Drying and storage	52	64.2
Record keeping	19	23.4
Disease control	73	90.1

Source**:** Field survey, 2021.

Table 7: Constraints to information access and used

Constraints	Frequency	Percentage
Inadequate extension contacts	3	3.7
High cost of inputs	47	58
High cost of labor	43	53.1
Distant from other farmers	11	13.6
Language barrier	10	12.3
Lack of adequate technical knowledge on recommended farm practices.	11	13.6
Telephone/GSM services	43	53.1
Ineffective communication	6	7.4

Source**:** Field survey, 2021.

CONCLUSION

It is concluded that agricultural extension services were delivered to the groundnut farmers in the study area, with extension agents as the main source of delivering such services. However, socio-economic factors such as household size, educational level and contact with extension agents influence the accessibility and utilization of such information or services. It is therefore recommended that services on record keeping should be strengthen to ensure adequate record data on their production activities.

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ACCESSIBILITY AND UTILIZATION OF INFORMATION COMMUNICATION TECHNOLOGIES (ICTS) AMONG EXTENSION WORKERS AND FARMERS IN MAKURDI, BENUE STATE, NIGERIA

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ABSTRACT

The study examined the level of ICT accessibility and utilization by farmers and extension workers in Makurdi, Benue State of Nigeria. Questionnaires were used to collect data from 120 respondents (60 extension workers and 60 farmers). The data were analyzed using descriptive and inferential statistics. The results show that majority (70%) of the extension workers and majority (60%) of the farmers were males within the age range of 40 – 53 years. Most (63.33%) of the extension workers were Diploma/NCE holders while 46.67% of the farmers had primary school education with farming experience within the range of 18-25 years. All (100%) extension workers and farmers had access to radio, while 96.67% and 46.67% of extension workers and farmers had access to television respectively. All (100%) of the extension workers had access to telephone with majority (83.33%) of the farmers also having access to telephone. Most (53.33%) of the extension workers complained of financial problem as the major factor militating against the use of ICTs while for the farmers 46.67% complained of inadequate awareness. Regression of some selected socio-economic characteristics of respondents on the level of utilization of ICTs shows R^2 value of 0.61. It further shows that there was a positive relationship between the levels of education of the respondents' utilization of ICTs which was significant at 5%. It was concluded that the use of ICTs among extension workers and farmers in Makurdi, Benue State as well as other states of the federation will help to promote participatory communication in the agricultural sector, and recommended adequate funding be provided to extension organizations to improve their ICT infrastructures, so as to enable staff utilize ICT facilities; and ICTs centers should be established in all parts of the State so as to create awareness among farmers.
***Keywords:** Accessibility, Utilization, Information Communication Technologies, Extension Workers, Farmers*

INTRODUCTION

Agriculture is one of the oldest industries and the origin can be traced to earliest human society. One of the major challenges to agricultural development in Nigeria and other African countries has been a low level of agricultural information exchanges among different stakeholders in the agricultural sector (Agwu, 2004).) Agricultural information is no doubt central in enhancing agricultural productivity and facilitating poverty alleviation among rural farmers (Adebayo 2006). There is a symbolic relationship between communication and development. The main purpose of agricultural extension is to assist farmers and their families to improve their living conditions. It involves dissemination of information on agricultural technologies and improved practices to farm families and ensuring farmers' capacity building through the use of communication and training methods. Accessibility of farmers to timely and relevant information will improve their agricultural production, processing and marketing. The improvements will translate into higher income and better living standards for the farmers (Ogunbameru, 2001). This can be feasible where there is adequate and accessible Information Communication Technologies (ICTs) for development.

A number of developments in recent times are shaping the future of extension services and are making way for the adoption of new and improved ICTs. A new paradigm of agricultural development is fast emerging, old ways of communication are being challenged and traditional societies are being transformed into knowledge societies all around the world. The use of ICTs is seen as means of achieving a great societal transformation. According to Shaik *et al*. (2004), when used as a broad tool for providing local farming communities with scientific knowledge, ICTs heralds the formation of knowledge societies in the rural areas of developing world. However, he advised that this can only be realized when knowledge and information are effectively harvested for agricultural and rural development. The use of ICT offers excellent possibilities for strengthening research-extension systems beyond the urban focus. Thus, for effectiveness and efficiency, extension service needs to be appropriately supported with the use of ICTs. A number of initiatives including the (CGNET), the USAID Leland initiative (1995 – 2002) and African highland initiative (1995 – 2000) have supported the establishment of communication networks in several countries of Africa. However, connectivity is still very much less than desired, and it could be argued that even for researchers in Nigeria, it is still less than the level at which significant impact can be expected (FARA, 2004). The study was conducted to examine the level of ICT accessibility and utilization among extension workers and farmers in Makurdi Metropolis, Benue State. Specifically, the study objectives were, to; describe the socio-economic characteristics; examine the level of accessibility and utilization of ICTs by the respondents; determine the effects of some selected socio-economic characteristics of the respondents on their level of utilization of ICTs; and identify constraints that hinder the effective use of ICTs in agriculture among respondents in the study area.

METHODOLOGY

The study was conducted in Makurdi, the headquarters of Benue state, located in the North central zone of Benue state, Nigeria. It lies between latitude 7º and longitude 8º north and east of the equator, and located in the guinea savannah of the Northern Nigeria. Makurdi is divided into two major blocks by River Benue hence the North and South Banks. It has a population of 2,261,990 million (NPC, 2006) with a land mass of 16km radius. Makurdi Local Government has a climate which falls within the humid tropical climate with wet season (March - October) and dry season (November – February). The average annual rainfall is about 1800mm and temperature range of 30ºCand 32ºC, which is high throughout the year (NPC, 2006).

The target population for this study included extension workers and farmers from Makurdi metropolis. A list of farmers was obtained from Benue state Agricultural Development Programme which was used to randomly select 15 respondents' farmers each from four wards within the metropolis. In addition, in the same vein, 15 extension workers from Benue State Agricultural Rural Development Authority (BNARDA) and 15 extension workers each from their three outlet Zones (Zone A, B and C) were randomly selected in the State giving an overall sample size of 120 respondents. (60 Extension Workers and 60 Farmers)

Data Analysis

Data were analyzed using descriptive statistics such as frequency counts, percentages, means and linear regression. The regression model is specified as follows

Regression model:

$Y_i= a+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+U$

Where:

Y_i= Level of ICT utilization (in percentage)

X_1= Gender (male=1, female=0)

X_2= Age of respondents (in years)

X_3= Computer literacy (yes= 1, No= 0)

X_4= Educational status (Non formal = 0, adult education = 1, primary = 2, secondary =3, diploma = 4, HND = others = 6)

X_5= Working/farming experience (in years)

a= Constant

U= Error term.

RESULTS AND DISCUSSION

Socio – Economic Characteristics of Respondents

Gender: Table 1 shows that majority (70%) of the extension workers and most (60%) of the farmers were males.

Age: About (33.33%) of the extension workers and (40%) of the farmers were found to be within the age range of 47 – 53 years and 40 – 46 years respectively. This is an indication that they are in their active and vibrant age. This shows a significant implication for ICTs utilization among this age group within their Middle Ages as they will give serious consideration to what they are doing even when it comes to using hi – tech innovation.

Educational Level: This shows that most (63.33%) of the extension agents had National Diploma while majority (46.67%) of the farmers had secondary school education.

Working experience: About (36.67%) of the extension workers had between 26 – 33 years working experience while 40% of the farmers had between 18 – 25 years farming experience. This implies that both sets of respondents are well experienced in their various fields.

Computer literacy: among the extension workers, it was found out that most (60%) of the respondents had computer education. It implies that the extension workers are better able to use ICTs in extension service delivery.

Major Occupation: Majority (90%) of the farmers are fully engaged in farming business with only (10%) into trading. This implies that agricultural farming practice plays an important role among the rural population in the study area.

Table 1: Distribution of Respondents According to their Socio-economic Characteristics

Variables	Extension workers		Farmers	
	Frequency	%	Frequency	%
Gender				
Male	42	70.00	36	60.00
Female	18	30.00	24	40.00
Total	**60**	**100.00**	**60**	**100.00**
Age (years)				
33 – 39	14	23.33	10	16.67
40 – 46	12	20.00	24	40.00
47 – 53	20	33.33	14	23.33
54 – 60	14	23.33	12	20.00
Total	**60**	**100.00**	**60**	**100.00**
Mean age for extension workers = 47.00, for farmers = 46.27				
Educational level				
Non formal	0	0.00	28	13.33
Adult education	0	0.00	4	6.67
Primary	0	0.00	8	13.33
Secondary	0	0.00	20	46.67
Diploma/NCE	38	63.33	0	0.00
HND/B.sc	12	20.00	0	0.00
Others	10	16.67	0	0.00
Total	**60**	**100.00**	**60**	**100.00**
Working experience (years)				
10 – 17	8	13.33	4	6.67
18 – 25	18	30.00	24	40.00
26 – 33	22	36.67	14	23.33
34 – 41	12	20.00	14	23.33
42 – 49	0	0	4	6.67
Total	**60**	**100.00**	**60**	**100.00**
Computer literacy				
Yes	36	60.00	-	-
No	24	40.00	-	-
Total	**60**	**100.00**		
Major occupation				
Farming	-	-	54	90.00
Trading	-	-	6	10.00
Total			**60**	**100.00**

Accessibility to ICTs

Table 2 shows that all (100%) of both extension workers and farmers in the study area had access to radio, 96.67% of the extension workers had access to television while 46.70% of the farmers had access to television. All (100%) of extension workers had access to telephone while 83.30% of the farmers had access to telephone. This could be attributed to the advent of mobile telephone which makes it easier for more people to have access to telephone services. Most (70%) of the extension workers had no access to personal computer while majority 80% of the farmers had no access to personal computer. Majority (73.30%) of the extension workers had access to the internet services while very few (20%) of the farmers had access to the internet services.

Table 2: Distribution of respondent according to ICTs accessibility

ICTs accessibility	Extension workers		Farmers	
	*Frequency	%	*Frequency	%
Radio	60	100.00	50	100.00
Television	58	96.67	28	46.67
Telephone	60	100.00	50	83.33
Personal computer	18	30.00	12	20.00

Access to Internet service	44	73.33	12	20.00

*Multiple Responses

Utilization of ICTs by Respondents for Agricultural Information.

Table 3 shows that majority (96.67%) of both sets of respondents listen to agricultural programmes using their radio sets while 93.33% of extension workers watch such programmes from the televisions, for the farmers about 46.67% of the respondents' view agricultural programmes from television. 36.67% of extension workers utilize internet while few of the farmers use the internet. 16.67% of extension workers use telephone for agricultural information while 23.33% of farmers use telephone for agricultural information. Thus, the radio and television can be effectively used for transmitting agricultural programmes to both extension workers and farmers.

Table 3: Distribution of Respondent according to the level of ICTs used

ICT Utilization	**Extension workers**		**Farmers**	
	*Frequency	%	*Frequency	%
Listen to Agric programme on radio	58	96.67	58	96.67
Watch Agric programme on TV	56	93.33	28	46.67
Use Telephone for Agric information	10	16.67	14	23.33
Use Computer that links to the Internet	22	36.67	12	20.00

*Multiple Response

Constraints to the Effective use of ICTs

Table 4 shows that most (53.33%) of the extension workers indicated lack of finance as the main problem while for the farmers about 46.67% indicated lack/inadequate awareness about ICTs. The respondents also noted that inability to operate computer, irregular electric supply, poor network /inaccessibility, inadequate cybercafé, and non-cooperation of staff. All these have caused a setback to ICT utilization. These findings agree with Arokoyo (2005) who reported that despite the fact that developing countries have adopted a variety of ICT tools that could be effectively used by extension; there are still very serious limitations for their use particularly in the rural areas.

Table 4: Distribution of respondents according to constraints encountered

Constraints	**Extension workers**		**Farmers**	
	***Frequency**	**%**	***Frequency**	**%**
Irregular electric supply	30	33.33	20	22.22
Financial problem	48	53.33	22	24.44
Inability to operate computer	36	40.00	20	22.22
Non – cooperation of staff	22	24.44	6	6.67
Poor network/Inaccessibility	24	26.67	18	20.00
Inadequate awareness about ICTs	38	42.22	42	46.67
Inadequate Cyber cafes	22	26.67	18	20.00

***Multiple Responses**

Regression of some Socio-Economic Characteristics on the Level of Utilization of ICTs by Respondents

Table 5 showed the effect of some socio-economic characteristics on the level of utilization of ICTs in a regression analysis. It showed that the combined effect of independent variables (gender, age, educational status, farming/working experience, computer literacy, major occupation) with coefficient of determination R^2 of 0.61 on the level of ICT utilization (Y) explained about 61% of ICT utilization at 5% significant level. Educational status was positive and significant at 5%. While four of the independent variables namely gender, age, farming/working experience (years), computer literacy, and major occupation, had no significant effect on level of ICTs utilization. The result implies that educational level affects the use of ICT positively in the study area. Thus, the more educated a respondent is, the more the probability of using ICTs for agricultural information which will consequently result in higher productivity.

Table 5: Regression Analysis showing the Coefficients on the Level of Utilization by the Respondents

Model	**Beta**	**Standard Error**	**T – Value**
Constant	- 0.184	0.574	-0.321^{NS}
Gender	0.133	0.090	1.481^{NS}
Age (years)	0.009	0.018	0.495^{NS}
Educational Level	0.155	0.044	3.540**
Farming/working experience (years)	- 0.009	0.015	-0.648^{NS}
Major occupation	- 0.033	0.148	-0.220^{NS}

$R^2 = 0.61$, $R^{-2} = 0.526$

** = significant at 5% level
Ns = Not significant

CONCLUSION AND RECOMMENDATIONS

The use of ICTs among extension workers and farmers in Makurdi Benue State as well as other states of the federation will help to promote participatory communication in the agricultural sector especially when people are educated, to appreciate and use these ICTs especially the modern ones, this will go a long way to improve the people's lives in the area of food security exposing more farmers to the importance of ICT for agricultural development. The study recommends adequate funding should be provided to extension organizations to improve their ICT infrastructures, so as to enable staff utilize these ICT facilities. Similar ICTs centers should be established in all parts of the state so as to create awareness among farmers. There is a need to organize frequent training for both extension workers and farmers in the use of ICTs facilities.

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AWARENESS LEVEL AND UTILIZATION PRACTICES OF ORANGE FLESHED SWEET POTATO AMONG FOOD VENDORS IN ABIA STATE, NIGERIA.

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ABSTRACT
The study conducted in Abia State, Nigeria aimed to assess the awareness and utilization practices of orange-fleshed sweet potatoes (OFSP) among food vendors. A total of sixty food vendors were randomly selected from Abia State's three agricultural zones, and data were collected through structured interviews. The data were analyzed using descriptive statistics such as frequency counts, percentages, and mean score. The findings revealed that a majority (70%) of the respondents were aware of OFSP, indicating a significant level of knowledge about the crop among food vendors in Abia State. However, challenges such as scarcity/unavailability of the crop and poor awareness/acceptance hindered its utilization. Boiling was the preferred method of preparing OFSP (45%), followed by frying (35%). The study recommends increasing knowledge about OFSP among food vendors through awareness campaigns, training programs, and dissemination of information on its nutritional benefits. Including OFSP in menus can enhance consumer acceptance and utilization, potentially addressing micronutrient deficiencies and improving food security and nutrition in Nigeria.
Keywords: *Awareness, Utilization, Sweet potato, Food vendors.*

INTRODUCTION
Sweet potato (*Ipomoea batatas* L.) is a crucial food security crop for millions of people in Sub-Saharan Africa and Asia. The crop is among the world's most important crops, ranking fifth and seventh in production in Africa and the World, respectively (Ashs, 2007, J. Low, 2007, CIP, 2007). It is mainly grown for human food and animal feed. It produces carbohydrate-rich storage roots with a substantial amount of vitamins A, B complex, C, and E, as well as minerals including calcium, potassium, and iron. According to Chowdhury *et al*. (2011), orange-fleshed sweet potato (OFSP) is particularly promising because its levels of provitamin A and carotenoids are high and can easily be absorbed by the body. Orange-fleshed sweet potato has emerged as one of the most promising plant sources of β-carotene, the pro-vitamin A (Hagenimana and Low, 2000). A 100- 150 g serving of boiled tubers of orange-fleshed sweet 3 potato can supply the daily requirement of vitamin A for young children which can protect them from blindness (Tsou and Hong, 1992).

Utilization of OFSP presents numerous advantages for Nigeria. Firstly, the high nutritional content of OFSP helps combat vitamins A deficiency, particularly in vulnerable populations such as pregnant women and young children. This can contribute to reducing the prevalence of associated health issues, including blindness and compromised immune systems. Foods high in vitamin A that are simple to make may consequently play a significant part in enhancing human health in these circumstances. The potential of "bio fortified" staple crops—varieties cultivated for higher vitamin or mineral content—has come to light over the past 15 years. Orange-fleshed sweet potatoes (OFSP) are particularly promising (Chowdhury et al. 2011), because they contain significant levels of provitamin A and carotenoids that are simple to absorb by the body. The crop presents a workable substitute that can promote economic expansion, poverty alleviation, and rural development. The purpose of this study is to ascertain the level of knowledge and OFSP usage among food vendors in Abia State, Nigeria.

METHODOLOGY
The research was conducted in Abia State, Nigeria. The three (3) Agricultural zones were purposively selected for the study. From each of these Agricultural zones, one local government area was chosen. The selected local government areas for the study were Aba South (in the Aba agricultural zone), Bende (in the Bende agricultural zone), and Umuahia North (in the Umuahia agricultural zone). A total of 60 food vendors were randomly selected and interviewed. Twenty food vendors were chosen from each of the three selected local government areas. The selection of food vendors was based on their active involvement in the food vending industry. Both qualitative

and quantitative information was elicited from the food vendors using a well-structured questionnaire and the data collected were analysed with descriptive statistics like mean, frequency, percentage and rating scale methods.

RESULTS AND DISCUSSION

Demographic characteristics of Respondents: (n=*60)*

Table 1 provides a frequency distribution of the respondents based on various characteristics. The results show that majority (80%) of the sampled food vendors were female while men (20%) implying that women were more in the food vending business than men.

The mean age of the respondents in the study area was 35 years implying that the food vending business is dominated by young energetic people. Age is typically seen as a primary latent trait in adoption decisions, according to Agbamu (2006). The result further shows that the majority (56.7%) of the respondents were married, 18.3% single, and 16.7% widowed, and 8.3% were divorced indicating that married people dominated in food vending business in the study area. The result also indicates that more than half (55%) of the respondents had a household size of less than 5 members, 25% had between 6-10 household size, 20% were respondents with household size that ranges from 11 and above in the study area. In terms of education, about (41.7%) of the respondents attained secondary, tertiary (30%), 23.3% had primary educational while 5 percent had no educational qualification. This is consistent with the findings of Adedoyin et al. (1999), who identified education as a foundation for farmers' use of agricultural products. It is generally accepted that education encourages a positive mental attitude toward innovative ideas and procedures. Only 36.7% had less than 5 years food vending experience, 28.3% had between 6-10years of experience, 23.3% had between 11-15 years' experience, while 11.7 percent had above 16 years of experience in the business.

Table 1: Demographic characteristics of the Farmers: (n=60)

Variables	Frequency	Percentage
Sex:		
Male	12	20
Female	48	80
Age:		
20-30	4	6.7
31-40	15	25
41-50	23	38.3
≥51	18	30
Marital status:		
Single	11	18.3
Married	34	56.7
Divorced	5	8.3
Widowed	10	16.7
HH size:		
≤5	33	55
6-10	15	25
≥11	12	20
Educational Level:		
None	3	5
Primary	14	23.3
Secondary	25	41.7
Tertiary	18	30
Years of experience in business:		
≤5	22	36.7
6-10	17	28.3
11-15	14	23.3
≥16	7	11.7

Source: Field survey 2022.

Awareness and Sources of OFSP Information.

The results in table 2 revealed that majority of respondents (70%) reported being aware of OFSP while (30%) of the respondents reported not being aware of OFSP. This indicates a relatively high level of awareness in the area. The most common source of OFSP information among the respondents was ADP (30%), Media sources (23.3%), Farmers (8.3%), and NRCRI/MOUAU (16.7%).

Table 2: Awareness and Sources of OFSP Information (n=60)

Variables	Frequency	Percentage
OFSP Awareness:		
Yes	42	70
No	18	30
Sources of OFSP Information:		
ADP	18	30
Media (Internet, print, radio, tv etc)	14	23.3
Farmer	5	8.3
NRCRI/MOUAU	10	16.7
Market	3	5
Family/Friends	3	5
Health workers	7	11.7

Source: Field survey 2022

Utilization of Orange Fleshed Sweet Potato in the study area.

The table 3 shows percentages for different food forms in terms of their utilization levels, ranging from "Very high" to "Very low." The result for raw form shows that (16.7%) respondents reported using it at a very low level, while only 5% used it at a very high level. The results show that boiling was the most popular way of utilizing OFSP among the respondents at (45%), while 1.7% used it at a very low level. The result shows that a significant proportion of respondents (20%) used OFSP leaves at a very low level. The results suggest that the utilization of OFSP in porridge form varied among the respondents, with 16.7% using it at a low level and 13.2% at a very high level. The table indicates that a significant proportion of respondents (30.2%) reported using OFSP in fried form at a very high level. However, 3.3% used it at a very low level. 20.7% used OFSP in juice form at a moderate level, while no respondents indicated using them flour, confectionaries, puree etc.

Table 3: Levels of Utilization of OFSP by the respondents (n=60)

Food form	Very high (%)	High (%)	Moderate (%)	Low (%)	Very low (%)
Raw/uncooked	5	13.3	11.7	8.3	16.7
Boiled	23.3	45	28.3	11.7	1.7
Leaves (as vegetables)	0	1.7	8.3	13.3	20
Porridge	13.2	5	6.7	16.7	11.7
Fried	30.2	6.7	15	15	3.3
Juice	0	3.3	20.7	3.3	10
Flour	0	0	0	5	0

Source: Field survey 2022

Constraints Militating against the Utilization of OFSP

Table 5 shows the factors militating against the utilization of Orange Fleshed Sweet Potato (OFSP) in the study area. The result reveals that 63.9% of the respondents indicated scarcity/unavailability as the major challenge they are facing, followed by poor awareness/acceptability (41.1%). Similarly, 22.5% and 20.8% of the respondents noted low demand and high cost of OFSP as another prevailing problem confronting them in the study area. Furthermore, 18% and 9.7% of the respondents indicated sensory attributes and post-harvest challenges as their minor challenges facing the utilization of OFSP in the study area.

Table 4: Constraints Militating against the Utilization of OFSP

Constraints	Frequency ((n-60) Percentage
Scarcity/unavailability	63.9
Post harvest challenges	9.7
Poor awareness/acceptability	41.1
Sensory attributes (texture, colour, taste etc)	18
Low demand	22.5
High cost of OFSP	20.8

***Multiple responses**

CONCLUSION AND RECOMMENDATIONS

The study findings revealed a high-level awareness of OFSP among the food vendors; they also indicated ADP and media as their major sources of OFSP information. The result also revealed that OFSP is utilized more as boiled and fried while scarcity/unavailability and poor awareness/acceptability were the major constraints militating against the use of OFSP in the study area The results also revealed percentages for different food forms

in terms of their utilization levels, ranging from "Very high" to "Very low." Majority reported Utilizing OFSP in boiled and fried form at high level, OFSP is utilized in low forms in raw and juice.
This study therefore recommends that there is need for increased awareness and sensitization of OFSP among the food vendors in Abia State and the need to include OFSP in their menu to encourage consumer's acceptance and utilization.

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ANALYSIS OF THE EFFECT OF SOCIO-ECONOMIC CHARACTERISTICS ON VALUE ADDITION AMONG RICE FARMERS IN IMO STATE.

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ABSTRACT

The study analyzed the effect of socioeconomic characteristics on value addition among rice farmers in Imo State. Nigeria. Data used for the study were collected with the aid of structured questionnaire administered to 150 randomly selected rice farmers. Data were analyzed using descriptive statistics and logit model. Result of the analysis showed that 44.7%, 30.6%, and 24.7% of the respondents have secondary, tertiary and primary education respectively. The result also reviewed that 56%, 36%, and 8% of the respondents had 6 – 10, 1 – 5, and 11 – 15 household members respectively. The results also indicated that the respondents that had 1–25, 26-50 extension contacts per year constituted 50% and 21%, respectively of the respondents; while 19% of the respondents had no contact with extension agents in the study area. Male rice farmers constitute 70% while 30% are female rice farmers. The result of age distribution shows that 50% of the rice farmers are between the age brackets of 51 to 60 years. This is followed by 30.6% of rice farmers in the study area who are between the age bracket of 41 to 50 years. The analysis noted that 14% and 4% are between 61 to 70 years and 31 to 40 years of age bracket respectively. The result also suggests that majority (64.7%) of the rice farmers have between 0.1 to 0.9 ha of rice farm. This is followed by 21.3% who had between 1 to 1.9 ha of rice farm. Rice farmers who had between 2 to 2.9ha and 3 to 3.9ha constitute 6% and 2% respectively. The result of the logistic analysis on the effect of socio-economic characteristics on value addition, showed that Household size, Gender, Age, Farm size and cooperative membership affected rice value addition. Hence socio-economic characteristics of rice farmers in the study area have significant effect on rice value addition. Value addition among rice farmers should be encouraged via good polices that would enhance gender participation and support large farm size.
Keywords: *Socio-economic characteristics, value addition, rice farmers.*

INTRODUCTION

The agricultural sector despite its significant decline in the share of Nigeria's GDP; from 63.8% in 1960 to about average of 24% during 2013 – 2019 (Fowowe, 2020; Oyaniran, 2020), and 22.35% between January and march 2021 (Sasu, 2023), is still the second-largest contributor to GDP growth (Varella, 2021), contributes significantly to rural development, food security and poverty alleviation (John et al., 2014.) and remains an important source of livelihood, economic development and creating employment for about 60% to 70% of the country's labour force (World Bank, 2014; Nigeria, FMARD 2016), an achievement which ranks the sector as the largest employer of labour in the country, Oyaniran,(2020). Nigeria, with a population of roughly 200 million, Africa's most populous country (Benson et al., 2020), is still largely characterized by production and direct sale of agricultural outputs in its raw form with very little capacity for transformation of produce from its raw form to other value-added products. This is attributed to inadequate capacity of primary producers to add value to their produce due to socio economic, technological and other constraints. According to FAO (2023), Nigeria's rice production rose from 3.7 million metric tons in 2017 to 4.0 million metric tons in 2018. In 2019, rice accounted for more than 14 percent of the crops cultivated by households in Nigeria, same year, the Government banned importation of rice in order to stimulate local production. In 2022, the quantity of milled rice produced in Nigeria was estimated at 5.4 million metric tons. Over the past few years, Nigeria has demonstrated a capacity to significantly increase paddy production. However, despite the annual increases in production, self-sufficiency in milled rice is yet to be attained due to mainly population growth which keeps increasing by 2.5-3.0% per annum and changes in consumers preferences influenced largely by growth in urbanization, NRDS II, (2020).

However, one important means of income generation that rural farmers have not paid much attention to is value addition (Obasi and Enyia, 2016). The poverty reducing potential of value addition is not only in generating rural income and employment but also by improvement in processing that reduce traditional food preparation times (Obasi and Enyia, 2016). value addition in the production of rice implies all the activities, processes or strategies and distribution of rice which in one way or the other contribute to benefit/utility maximization (Ugwu et al., 2014). This study considered value addition to be any improvement made to rice paddy to bring it to a form in which the consumer wants it. It ensures that the small-scale household does not suffer the biophysical losses, economic loss and nutrient losses and also minimizes the causes of total food loss during harvesting, food storage, processing, packaging, marketing and consumption losses. Despite the numerous benefits of value addition, majority of the rice farmers have continued to trade their produce in raw form. This could be linked to lack of capacity as well as processing equipment and socio-economic characteristics of rice farmers. The study is therefore, intended to; i. ascertain the socio-economic characteristics of the rice farmers in the study area, ii. determine the effects of socio-economic characteristics on rice value addition and also test if the socio-economic characteristics of rice farmers have any significant influence on rice value addition.

MATERIALS AND METHOD.

This study was conducted in Imo state, Nigeria. Imo State lies between Latitude $5^0 10'$ and $6^0 35'$ North of the equator and between Longitude $6^0 35'$ and $7^0 31'$ East of the Greenwich meridian. The State has a population of about 3,934 million people disaggregated into 2,032 males and 1,903 million females (NPC, 2006). It is bounded on the East by Abia state, on the North by Anambra and Abia State, and on the West by Rivers State. The State is divided into 27 administrative units called Local Government Areas which are grouped into 3 agricultural zones viz Owerri, Okigwe and Orlu. The population for our study comprised of rice farmers in Imo State. This study adopted multistage random and purposive sampling techniques. In the first stage, two of the major rice producing-agricultural zone in Imo state, were purposively selected. This is to ensure that the zones that are predominantly rice farmers are selected. Based on this, Okigwe and Orlu agricultural zones were chosen. From the two agricultural zone, two LGAs (Ihitte Uboma and Okigwe for Okigwe Zone), and (Ideato Noth and Ideato South for Orlu Zone) were purposively selected to give a total of four (4) LGAs. This was based on the concentration of rice farmers in the LGAs. The third stage involved the random sampling of 150 respondents from the list of rice farmers obtained from Imo State RIFAN. The selection of the respondents was done proportionately to ensure that LGA with more rice farmers had more respondents. Data were sourced principally through primary source. Data were obtained with the aid of structured questionnaire that was administered in-person to the sampled respondents. Data were analyzed using simple descriptive statistical tools and Logit model which is expressed as; $Li\ Y = Ln\ (P/1\text{-}P)$ (1).

$Ln\ (P/I\text{-}P) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_7 x_7$ (2).

Detailed description of the variables is as shown below.

Y = value addition (dummy variable, 1 for adding value, 0 for not adding value)

X_1 = household size (number of persons)

X_2 = gender (dummy variable, 1 for male, 0 for female)

X_3 = Age of the household head (years)

X_4 = Educational level (number of years spent in school)

X_5 = Extension visit (number of visits)

X_6 = Cooperative membership (dummy variable, 1 for member, 0 for non-member)

X_7 = farm size (hactare)

RESULTS AND DISCUSSION

The results in Table 1 showed that 44.7% of the respondents in the study area have secondary education, followed by 30.6% of the respondents who have tertiary education. The finding also showed that 24.7% have primary education. The finding suggests that there is high level of literacy among rice farmers in the study area. The result disclosed that majority (56%) had 6 – 10 persons, followed by 36% who had 1 – 5 persons. Only 8% had 11 – 15 persons. This may indicate that respondents in the study area have large household sizes. The result also showed that 50% of the rice farmers had between 1 – 25 contacts per year, 21% of the rice farmers had between 26 – 50 extension contact while 19% had no contact with extension agents in the study area. Male rice farmers constitute 70% while 30% are female rice farmers. The result of age distribution shows that 50% of the rice farmers are between the age bracket of 51 to 60 years. This is followed by 30.6% of rice farmers in the study area who are between the age bracket of 41 to 50 years. The data showed that 14% and 4% are between 61 to 70 years and 31 to 40 years of age respectively. The result also suggests that majority (64.7%) of the rice farmers have between 0.1 to 0.9 ha of rice farm. This is followed by 21.3% who had between 1 to 1.9 ha of rice farm. Rice farmers who had between 2 to 2.9ha and 3 to 3.9ha constitute 6% and 2% respectively. This result indicates that majority of the rice farmers in the study area are small scale rice farmers.

Table 1. Socio-economic characteristics of the respondents in the study Area.

Education level (years)	Frequency	Percentage	Mean
1 – 6	37	24.7	
7 – 12	67	44.7	
13 - 16	46	30.6	
Total	**150**	**100**	**9.6**
Household Size (person)			
1 – 5	54	36	
6 – 10	84	56	
11-20	12	8	
Total	**150**	**100**	**7**
Extension Visit (no/year)			
None	28	19	
1 – 25	75	50	
26 – 50	32	21	
51 – 75	15	10	
≥ 76	0	0	
Total	**150**	**100**	**21**
Gender			
Male	105	70	
Female	45	30	
Total	**150**	**100**	
Age (years)			
≤ 30	1	0.7	
31 – 40	6	4	
41 – 50	46	30.6	
51 – 60	75	50	
61 – 70	21	14	
≥ 71	1	0.7	
Total	**150**	**100**	**53**
Farm Size (Ha)			
0.1 - 0.9	97	64.7	
1 - 1.9	32	21.3	
2 – 2.9	9	6	
3 – 3.9	3	2	
Total	**150**	**100**	**0.85**

Source: Survey data 2022.

The result in Table 2 showed that household size was statistically significant at 1% level and positively related to value addition. This implies that household size influences value addition that is households with more members participate more in value addition. The result also showed that gender was negative and statistically significant at 1% level. This suggests that value addition is gender biased. Age was found to be statistically significant at 1% level and positively related to value addition. This indicates that age influences value addition. Hence, older farmers participate more in value addition. Education was negative and statistically non-significant with value addition. This implies that the knowledge/skill required to participate in value addition could be acquired informally. Extension contact was found to be positive and statistically non-significant. This shows that Extension contact has no influence on value addition, and could be attributed to the fact that extension agents dwell more on production activities than post-harvest activities. Cooperative membership was found to be statistically significant at 5% level and negatively related to value addition. This implies that value addition is not dependent on cooperative membership. Farm size was found to be statistically significant at 1% level and positively related to value addition. This direct relationship implies that farm size influences participation in value addition.

Table 2: Result of logit regression on the effect of socio-economic characteristics on rice value addition

Variables	Coeff.	Std.Err.	Z	P>|Z |	Marginal effects
Household Size(X_1)	0.299	0.014	3.35**	0.001	0.046
Gender (X_2)	-1.697	0.118	-2.66**	0.008	-0.315
Age (X_3)	0.130	0.006	3.02**	0.003	0.020
Education Level(X_4)	-0.077	0.009	-1.31	0.190	-0.012
Extension Visit(X_5)	0.004	0.001	0.48	0.632	0.000
Coop Membership (X_6)	-1.585	0.159	-2.08*	0.037	-0.332

Farm Size (X_7)	1.267	0.066	2.96**	0.003	0.198
constant	-7.774	2.567	-3.03**	0.002	
log likelihood =	-64.403769				
LR $chi^2(7)$ =	49.08				
Pseudo R^2 =	0.0000				
Number of Obs	150				

Source: Survey data 2022 *Significant @ 5% level, **significant @ 1% level.

Hypothesis on the significant effect of socio-economic characteristics on rice value addition.

H_O: Socio-economic characteristics (X_1, X_2, X_3, X_4, X_5, X_5 & X_7) of the rice farmers have no significant influence on their value addition.

H_A: Socio-economic characteristics (X_1, X_2, X_3, X_4, X_5, X_5 & X_7) of the rice farmers have significant influence on their value addition.

To test this hypothesis, the logistic analysis already performed to achieve objective (ii) was re-employed. The result is presented in Table 3.2. The table showed that the chi-squared calculated was significant at 5% level of probability and concluded that the factors indicated actually affected rice farmers value addition. Therefore, the null hypothesis which stated that socio-economic characteristics of rice farmers have no significant effect on rice value addition was rejected.

CONCLUSION AND RECOMMENDATION

Based on the finding of this study, it could be concluded that value addition among rice farmers in the study area is influenced by socio-economic characteristic namely, Household size, Gender, Age, Farm size and Cooperative membership. Besides, rice farmers in the study area are small scale farmers of large household size, whose active and productive age falls within 41 to 60 years of age bracket with relatively high literacy level and poor extension contact. Value addition among rice farmers should be encouraged via good polices that would enhance gender participation and support large farm size among rice farmers. Government should create enabling environment to enable rice farmers queue into value addition which increases the shelf life of rice and in turn enhances rice farmers income generation and food security.

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EFFECT OF SOCIO-ECONOMIC FACTORS ON PROFITABILITY OF CASSAVA PRODUCTION IN EHIME MBANO LGA, IMO STATE, NIGERIA

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ABSTRACT
The study examined the impact of socio-economic factors on profitability of cassava production in Ehime Mbano LGA Imo state. Specifically, it described the socio-economic characteristics of cassava farmers, determined the profitability of cassava farming, and determined the impact of socio-economic factors of cassava farmers on profitability of cassava production. Study area was in Ehime Mbano LGA of Imo state. Data were collected with a structured questionnaire from 80 randomly selected cassava farmers. Data were analysed using descriptive (frequency, percentage and means) and inferential statistics (regression analysis). The result showed that 51.3% of the respondents were males, the mean age of respondents is recorded at 33 years, most of the respondents (72.5%) were married, 46.3% of respondents had only secondary school qualification and the average household size of the respondents is made up 6 people. Cassava farming was profitable in the study area with a Net Rate of Return of 97%. The multiple regression with R^2 of 0.593 indicates that the model explains 59.3% of the variation in cassava production. Household size had a positive significance on cassava profitability while education had a negative significance on cassava profitability in the study area. To strengthen agriculture for food and nutrition security and export in a climate change environment, government and agencies should carry out sustainable cassava production programmes and policies to encourage and sustain cassava production.
Keywords: *Impact, Cassava, Profitability*

INTRODUCTION
Cassava is one of the most important crops grown in Nigeria with an annual production of over 60 million tonnes making it the world's largest cassava producer and it is crucial to the development of Nigeria's agro economy as it is consumed both locally and used as a raw material (Ikuemonisan *et al*., 2020). Cassava products are generally accepted by all classes of Nigerians, which makes it attractive to farmers (Itam *et al.*, 2014). Cassava tends to thrive where other crops fail even on marginal soils and a moderate climate (Omodara *et al*., 2023). Despite its leading position in cassava production, Nigeria remains an importer of cassava products (Olukunle, 2016). Cassava is an agricultural produce with the potential to generate foreign exchange for Nigeria through the exportation of the crop. However, the nature of its production which is moistly in the rural areas faces plethora of challenges which has affected its productivity (Inegbedion *et al.*, 2020). Majority of cassava in Nigeria is produced by farmers in the rural areas and forms a vitally important role in the survival of the rural dwellers, there challenges facing cassava production and if these challenges persist it could lead to a potential setback in cassava production (Oyekola *et al.*, 2021). There is a great potential both for export and domestic consumption for cassava. Its usefulness as a wide spectrum, range from the leaves to the roots which are mostly used for animal feeds and food processing (Itam *et al.,* 2014).
In Nigeria, the consumption of cassava varied from 35.6 million tonnes in 2002 to 52.4 million tonnes in 2011 while a major proportion of cassava produced in Nigeria goes to human consumption while a very low proportion goes to industry and foreign trade. According to Faborode (2016), the Nigerian economy is indeed mono-cultural with the dominance of oil overshadowing sectors such as agriculture and manufacturing. The impact on development has been low welfare capacity, low employment, high inequality and hence high multidimensional poverty or the paradox of poverty during plenty (Olukunle, 2016). While cassava plays a significant role in the survival of rural dwellers, the farmers still face challenges in producing cassava in substantial quantity (Shakleton, 2020). Thus, if these challenges remain unchecked, it can cause serious drawback to both social and economic development. Hence this study aims to describe the socio-economic characteristics of cassava farmers, determine

the profitability of cassava farming, and determine the impact of socio-economic characteristics of cassava farmers on profitability.

MATERIALS AND METHODS

Study Area

Ehime Mbano is a Local Government Area of Imo state Nigeria. It is located at Latitude 5^0 40' 54 North and Longitude 7^0 18' 11 East and is bounded in the East by Isiala Mbano L.G.A, in the West by Ahiazu Mbaise L.G.A, in the North by Okigwe L.G.A and in the South by Ihitte Uboma LGA. It has an area 169 Square km and a population of 130,931 (NPC, 2006).

Sampling procedure

A multistage ppurposive and random sampling technique was used for the selection of respondents for this study. Purposive sampling technique was used to select four (4) towns (Nsu, Ehim, Umue-Zeala and Umun-Akanu) due to their high involvement in cassava farming. Secondly from the four towns selected, two (2) villages were randomly selected. Thirdly, ten (10) cassava farmers were randomly chosen each from the villages selected. Hence the sample size of cassava farmers used for this study was eighty (80) respondents inclusive of both Male and Female.

Data Analysiss

Descriptive statistical tools involving percentages, means, and frequency distribution tables were used to analyze data generated on socio- economic characteristics. The variables were fitted with functional forms of multiple regression, results were based on the significant parameters and overall significance of the estimated model. Gross margin was estimated, and this is indicative of farmers' productive capacity while the net profit gives an indication of the actual returns profile after deducting the fixed cost components from the gross revenue. Gross margin and net profits were estimated to assess the level of profitability of cassava enterprise.

Profitability of the enterprise is mathematically expressed as:

GM=TR-TVC

NPI=GM-TFC=TR-TC

GRR=GM/TVC)

NRR = NPI/TC

Where,

GM = Gross Margin.

TR = Total revenue

TVC = Total Variable Cost.

TFC = Total Fixed Cost

TC = Total Cost

NPI = Net Production Income= Net Profit

GRR= Gross Rate of return on Investment.

NRR = Net Rate of Return on Investment.

RESULTS AND DISCUSSION

Socio-economic characteristics of the respondents

The socio-economic characteristic under consideration includes gender, age, marital status, educational qualification, and household size of the respondents.

Figures in table1 shows that most of the respondents used for this study were males accounting for 51.3% while 48.8% of the respondents were females. This could be because the male gender is more involved in farm level production while the female gender tends towards processing. This is in line with a study by Suleiman *et al.* (2017) which stated that males are labour efficient which leads to higher productivity. The results also shows that the mean age of the respondents is recorded at 33 years. This indicates that majority of the respondents for this study are young and active. This is in line with a study by Aminu and Okeowo (2016) which stated that younger people are the most dominant in crop farming.

The results also shows that most of the respondents are married, which constituted 72.5% of the respondents. the respondents that are single and have never been married constitutes 27.5% of the respondents. The preponderance of married people can be an incentive for more farm labour supply which can directly lead to a higher cassava production. This is in line with a study by Olukunle (2016) which states that most rural farm dwellers are married and contributes positively to labour for cassava production. Results also shows that most respondents had only secondary school qualification as represented by 46.3% of the respondents, those with tertiary level education qualification are represented by 27.5% of the respondents, those without any form of formal education are represented by 15.0% of the respondents and farmers with only primary school qualification are comprised of 11.3% of the respondents. This indicates that majority of the sample used for this study had one form or another of formal education. This is in line with a study by Dauda *et al.* (2015) which stated that farmers in the rural areas have a form of formal education. Findings also shows that the average household size of the respondents is 6 people. This implies that most of the respondents have a household size of more than 4 people living under the same roof. This is in line with a study by Suleiman *et al*. (2017) which stated that that most of farmers had large household size of 4-6 members which will enhance family labour availability.

Table 1 Socioeconomic characteristics of the respondents

Variable	Frequency	Percentage	Mean
Gender			
Male	41	51.3	
Female	39	48.8	
Age distribution (years)			
16-25	25	31.3	33 years
26-35	30	37.5	
36-45	16	20.0	
46-55	9	11.3	
Marital status			
Married	58	72.5	
Single	22	27.5	
Educational qualification			
No formal education	12	15.0	
Primary qualification	9	11.3	
Secondary qualification	37	46.3	
Tertiary education qual	22	27.5	
Household size (people)			
1-3	13	16.3	6 people
4-6	37	46.3	
7-9	20	25.0	
10-12	10	12.5	

Average profitability of cassava production/ hectare

The results in Table 2 shows that on the average profitability per hectare of cassava farming, the total cost consists of ₦9,905.48 as variable cost and ₦18,391.28 as fixed cost component. Based on the gross revenue realized per metric tonne of output, profitability indicator was ₦43,740. Gross margin and net profit per metric tonne of cassava output at the farm level were positive. The gross margin at the farm level was ₦33,835 while the net profit was ₦15,443. In terms of rates of returns, the net rate of return was 97% based on net profit. The net rate of return of 97% implies that for every one Naira (100 kobo) invested in cassava production by an average cassava farmer at the small-scale level, there is a net profit of 97 kobo.

Table 2 Indicators of profitability of cassava production per hectare

Category	**Amount NGN/ Ha**
Variable Cost Components:	
Cost of manure	10000
Planting material cost	12500
Cost of herbicides/pesticides	15000
Total labour cost	75000
Transportation cost	40000
Total Variable Cost (TVC)	152,500
Fixed Cost Components:	
Land	55,000
Farming tools	16,700
Interest paid	10,000

Total Fixed Cost (TFC)	81,700
Total Cost (TC) = TVC + TFC	234,200
Profitability Indicators:	
Gross Revenue (Quantity of output multiplied by price of output)	460,300
Gross Margin = GR-TVC	307,800
Net Profit= GR-TC	226,100
Gross Rate of Return= GM/TVC	2.01
Net Rate of Return=NP/TC	0.97

Impact of the socio-economic characteristics of farmers on cassava profitability.

Table 3 shows that the overall regression model was significant, which indicates that the variables measured have a significant impact on profitability of cassava production. F (4,41) = 14.93, p <.001, R^2=.593). Also, R^2 =0.593 which depicts the model explains 59.3% of the variation in cassava production. Coefficients were further assessed to ascertain the influence of each of the socio-economic factors on profitability of cassava production and the results revealed that Household size has a positive significance on cassava profitability while education has a negative significance on cassava production. The positive significance of household size is against the findings of Suleiman *et al.* (2017).

Table 3 Socio-economic characteristics impacting profitability of cassava production.

Variables	B	T-value	p-value
Constant	11.809	1.682	0.100
Gender	-2.630	-1.654	0.106
Age	2.369	1.139	0.261
Educational qualification	-0.280	-2.163	0.036*
Household size	4.701	3.867	0.000*
R^2	0.593		
F (4,41)	14.93		

*Note. *p < 0.05*

CONCLUSION AND RECOMMENDATIONS

Based on the findings from this study, it was concluded that cassava farming was profitable in the study area. Household size and educational qualifications are the factors affecting profitability of cassava production. To strengthen agriculture for food and nutrition security and export in a climate change environment through cassava production, government and private agencies should carry out sustainable cassava production programmes and policies to encourage cassava production.

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SOCIOECONOMIC IMPORTANCE OF BAMBOO (*BAMBUSA VULGARIS*) IN ALAMALA BARRACKS AND SOYOYE, ABEOKUTA, OGUN STATE, NIGERIA

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ABSTRACT

This study evaluated the socio-economic importance of Bamboo among residents of Alamala Barracks and Soyoye area of Ogun state. Structured questionnaire was used to collected data from randomly selected 100 respondents. Data were analysed using percentage and correlation. Findings revealed that modal ages were 33 years and 23 years in Soyoye and Alamala Barracks respectively. The majority (74.3%) of the respondents in Alamala Barracks were males as well as 57.5% in Soyoye. Furthermore, 51.4% had a tertiary form of education in Alamala barracks as against 38% in Soyoye. Bamboo usage among the community residents revealed that 82% use it for construction in Soyoye as against same percentage for decoration in Alamala barracks. Spearman's Rank Correlation value of 0.0857 implied a low correlation between bamboo usage rates across the two communities in spite of their closeness. Bamboo was largely used for recreational and aesthetic activities in Alamala Barracks as against economic benefits for most Soyoye residents. Therefore, increased cultivation of Bamboo through awareness and support programs is recommended because of the enormous benefits of the plant in the two communities. Also profitable investment can be made from Bamboo in Soyee and Alamala Barracks.
Keywords: *Benefits, Bamboo, Correlation, Soyeye, Alama Barracks, Ogun State*

INTRODUCTION

Bamboo (*Bambusa*) is a drought-resistant perennial woody grass belonging to the group angiosperm and the order monocotyledon. They are in the sub-family of *bambusoideae* and family *poacae*. Forest composition was assessed in the last century in terms of the commercial value of timber in Nigeria, Bamboo was found in a number of states particularly in the southern part of the country (Nwaihu, *et. al*, 2015). According to a report by Raw Materials Research and Development Council in 2004, the most endowed states in terms of bamboo occurrence were observed to be Ogun, Oyo, Osun, Ondo, Edo, Delta, Rivers, Akwa Ibom, Cross River, Abia, Ebonyi, Enugu, Anambra and Imo States and at least 10% of the natural vegetation in these states is dominated by bamboo, with existing bamboo clumps showing appreciable gregarious growth that is contiguous over large areas. The report also indicated availability of bamboo in Niger, Taraba, and Plateau states as well as within the Federal Capital Territory (Asiru, *et al*, 2017).

Bamboo is an important renewable resource that when managed properly can bring people out of poverty, thereby improving the economy of the country (Satish, *et al*., 2020). This is why it is of utmost importance to identify the various uses of Bamboo trees and the benefits that can be derived from its parts to the people of Alamala Barracks and Soyeye areas of Ogun state.

The lack of information on the socioeconomic importance of Bamboo species has been linked to the non-sustainable utilization of many of these species in some parts of Nigeria. Recently in Nigeria, the prospects for multi-functional utilization were on the increase due to increased dependence on the importation of raw materials and the obvious ecological and land degradation taking place in most parts of the country (Ogunwusi, *et al*., 2013). This study aims to describe the socio-economic importance of Bamboo in Alamala Barracks and Soyeye areas of Ogun state, Nigeria.

METHODOLOGY

Alamala Barracks was built as a military barrack, where troops of various sizes and complexity in the Nigerian Military and their families are quartered. It is situated in Abeokuta North, Ogun state, Nigeria, its geographical coordinates are 7° 11' 0" North, 3° 14' 0" East. Zip Code: 110101 with Latitude: 7.17239 Longitude: 3.27902 and Soyoye, is located at Abeokuta, Nigeria with coordinates of Latitude: 7.16987 and Longitude: 3.273982. The study areas; Alamala barracks and Soyoye community were selected purposively based on their prominence for bamboo cultivation and utilization. A set of structured questionnaires were randomly distributed to 100 respondents but only 75 questionnaires were retrieved. Data collected were analysed using percentage and Spearman's Rank Correlation.

RESULTS AND DISCUSSION

Table 1: Socio-economic characteristics of the Respondents (N=75)

Variable		Soyoye (%) N=40	Mode	Alamala (%) N=35	Barracks	Mode
Age (years)	<20	2 (5.0)		5 (14.3)		
	20-30	9 (22.5)		17 (48.6)		**23years**
	31-40	17 (42.5)	**33years**	11 (31.4)		
	41-50	11 (27.5)		1 (2.9)		
	51-60	1 (2.5)		0 (0.0)		
	>60	0 (0.0)		1 (2.9)		
Gender	Male	23 (57.5)	**Male**	26 (74.3)		**Male**
	Female	17 (42.5)		9 (25.7)		
Ethnicity	Yoruba	30 (75.0)	**Yoruba**	16 (45.7)		
	Hausa	1 (2.5)		17 (48.6)		**Hausa**
	Igbo	3 (7.5)		2 (5.7)		
	Others (Ijaw& Egun)	6 (15.0)		0 (0.0)		
Religion	Christianity	16 (40.0)		16 (45.7)		
	Islam	20 (50.0)	**Islam**	19 (54.3)		**Islam**
	Others	4 (10.0)		0 (0.0)		
Marital status	Single	3 (7.5)		11 (31.4)		
	Married	30 (75.0)	**Married**	24 (68.6)		**Married**
	Widowed	2 (5.0)		0 (0.0)		
	Others	5 (12.5)		0 (0.0)		
Household size	<3	5 (12.5)		9 (25.7)		
	(3-5)	12 (30.0)	**3-5**	12 (34.3)		**3**
	>5-7	14 (35.0)		4 (11.4)		
	Others	9 (22.5)		10 (28.6)		
Educational status	Primary	5 (12.5)		3 (8.6)		
	Secondary	16 (40.0)	**Secondary**	13 (37.1)		
	Tertiary	15 (37.5)		18 (51.4)		**Tertiary**
	No formal education	4 (10)		1 (2.9)		
Occupation	Artisan	5 (12.5)		2 (5.7)		
	Farmer	5 (12.5)		0 (0.0)		
	Trader	17 (42.5)	**Trader**	2 (5.7)		
	Civil Servant	11 (27.5)		31 (88.6)		**Civil Servant**
	Student	1 (2.5)		0 (0.0)		
	Others	1 (2.5)		0 (0.0)		
Monthly income	<₦10,000	8 (20.0)		0 (0.0)		
	₦10,000-19,999	9 (22.5)		0 (0.0)		
	₦20,000-29,999	8 (20.0)		9 (25.7)		
	₦30,000-39,999	12 (30.0)	**₦30,000**	13 (37.1)		**₦35,000**
	₦40,000-49,999	3 (7.5)		12 (34.3)		
	>₦50,000	0 (0.0)		1 (2.9)		

Source: Field Survey, 2022. **Values in parenthesis are in percentages (%)**

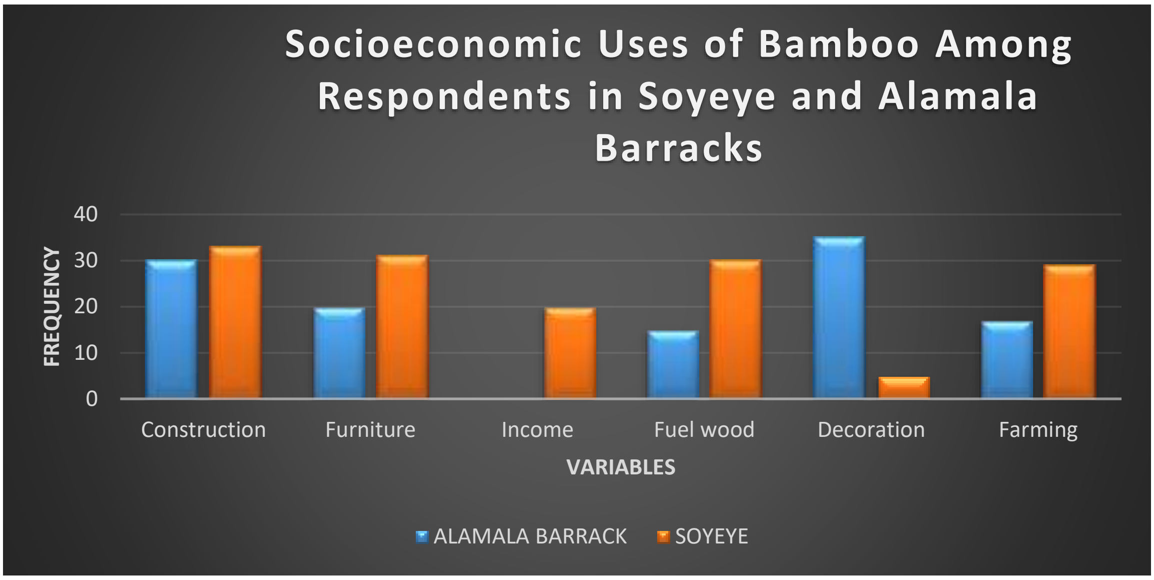

Figure 1: Socioeconomic uses of Bamboo in the study areas

Socio-economic uses of Bamboo

The result highlights the socio-economic uses of bamboo in Alamala barracks by the respondents. Majority of the respondents said bamboo tree is mainly used for decoration, it is also used for construction, some said it is used in furniture making while less than half said the tree is used in farming and fuel wood respectively. These findings showed that Bamboo is highly good for decorations and also agreed with the report of (Ijeomah, 2007). While in Soyoye, a majority said bamboo is used for construction, some said it is used in furniture making, construction of houses, huts, fences, walking sticks, chairs, baskets, beds, and various artifacts. The use of Bamboo as a main construction material is in agreement with (Akoto *et al.*, 2018; Okokpujie *et al.*, 2020) as it is considered a cheaper and viable alternative for housing due to its strength, flexibility, and versatility.

Correlation between the Study Areas

Correlation revealed that X and Y variables represent the frequency of responses from Soyoye and Alamala Barracks respectively on the economic uses of Bamboo plants. Spearman's rank correlation value equals 0.0857, this showed that the correlation value is low (close to zero) and so no significant relationship or association between the two study areas despite their closeness and similarity in the use of the plant. The two areas are said to be independent of one another. Technically, the response from on locality cannot be used to predict the other quantitatively.

Table 2: Relationship between the uses of Bamboo in Soyoye and Alamala Barracks

X	Y	Rx	Ry	d = Rx – Ry	d²
33	30	1	2	-1	1
31	20	2	3	-1	1
20	0	4	6	-2	4
10	15	5	5	0	0
5	35	6	1	5	25
29	17	3	4	-1	1

$\sum d^2 = 32$ $\quad n = 6$

$\rho = 1 - (6 \sum d_i^2 / n (n^2 - 1))$

$= 1 - (6 \times 32/6 \times (36 - 1))$

$= 1 - (192/210)$

$= 1 - 0.9143$

$= 0.0857$

Analysis of the socioeconomic characteristics of the respondents showed that the majority of the respondents in both study areas were males and in their youthful and active period with ages ranging from 20-30 years and 31–40 years in Alamala Barracks and Soyoye respectively which means they are expected to be cognizance of the happenings in their community and is in agreement with (Ogunjinmi *et al.*, 2009) who reported that the respondents should be knowledgeable and able to give reliable information as matured males were involved in harvesting of bamboo. The marital status of the respondent in Soyoye and Alamala Barracks revealed that the proportion of married outweighed that of single which is also in agreement with (Nwaihu *et al.*, 2015) that had more married respondents in their research on Bamboo utilization in Imo State. The majority of the respondents in Alamala Barracks had tertiary education, as against that of Soyoye who had only a few but more with no formal education. This implied that Alamala Barracks residents were majorly working class with higher education qualifications while Soyoye had more artisans because of the educational level. This may have a negative impact on bamboo resource management as reported by (Shiferaw *et al.*, 2021) that resources can be more conserved and maintained appropriately if the community acquires education and has good knowledge resources and vice versa.

CONCLUSION

This study described Bamboo as a non-timber forest product that finds its enormous use in recreational and aesthetic activities for the people of Alamala Barracks may be because the respondents of the study areas do not really engage in farming, but were dominantly civil servants while in Soyoye, bamboo use ranges from construction, traditional medicine, furniture and to main source of income as majority of the respondents were traders. However, there was no significant relationship or association between Alamala Barracks and Soyoye regarding the various uses of Bamboo in the two localities. This fact is evident in the correlation coefficient of 0.0857 as estimated from the variables.

RECOMMENDATION

Based on the enormous benefits derived from the use of Bamboo in the study areas, the government or private sector should encourage more cultivation through various awareness and supports programmes. Also profitable investment can be made from Bamboo in Soyee and Alamala Barracks of Ogun state, Nigeria.

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RURAL AMENITY – BASED: A VERITABLE TOOL TO ENHANCE EXTENSION AGENTS IN DELIVERING INFORMATION ON CASSAVA PRODUCTION TO FARMERS FOR FOOD SECURITY IN DELTA STATE

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ABSTRACT

The study was carried out to determine rural amenity-based as a veritable to enhance extension agents' effectiveness in delivering information on cassava production to rural farmers for food security in Delta State. Two purposes and two research questions guided the study. The work specifically adopted a survey research design. The population of the study was 200 which consisted of 120 extension agents and 80 agricultural education lecturers in tertiary institutions of Delta State. There was no sampling because the whole population was of the manageable size. The questionnaire was face validated by three experts from agricultural Education Department, Federal College of Education (Technical) Asaba, Delta State. The instrument used for data collection was questionnaire tagged ''veritable tool to enhance extension agents in delivering information on cassava production to rural farmers questionnaire'' (VTEEAEDICPRFQ) consisting of 27 items was developed from the literature and used as the instrument for data collection. The scale for questionnaire was: Strongly Agreed (SA)-4, Agreed (A)-3, Disagreed (D)-2, Strongly Disagreed (SD)-1. 200 copies of the questionnaire were distributed to respondents but 193 copies were returned which was at 97% return rate. The data collected were analyzed using mean and standard deviations to answer the research questions. The result of analysis showed that provision of electricity, and construction of good road network can enhance extension agent in delivering information to rural farmers on cassava production for food security in Delta State. Based on the result of the study, it is recommended that Delta State government through the ministry of agriculture should provide amenities in the rural areas such as good road network and electricity to the rural areas to enhance extension agents in delivering information to farmers.

Keywords: *Rural Amenity, information, extension agents, rural farmers, cassava, and food security.*

INTRODUCTION

Cassava (*Manihot esculenta*) is a major food and industrial crop in the tropical and sub-tropical Africa. It is a major food in Nigeria particularly, Delta State. According to Okeme *et al.* (2020), cassava is a drought tolerant, famine reserve crop and can withstand extended period of drought and some varieties can survive on annual rainfall of only 200mm if suitably distributed. Cassava production as used in this study entails all processes geared towards making sure that farmers obtain innovative information on cassava production to ensure food security.

Food security simply means an assurance and an access to sufficient quantities and quality of food in the right proportion for all, including the poor (Ayansina and Adeogun, 2017). Food security is achieved when the people in all States of Nigeria have access to sufficient safe and nutritious food to meet the dietary needs and food preference for an active and healthy life (Egbe *et al*., 2022). According to (Agholor, 2016), the reason why the farmers are still using traditional based approach is lack of knowledge on innovative ideas to apply modern techniques in commercial agriculture. In submission of (Adesiji *et al*., 2010), farmers need timely agricultural information from the extension agents.

Agricultural extension agents are the trained persons in extension education who are made to spread agricultural information to rural farmers (Okeowo, 2015). Okeowo, stated further that extension agents train farmers, provide advisory services and information to farmers, also help them form organization for sustainable food production and marketing, as well as teaching rural farmers on improved cultivation, rearing of animals and processing of crops. Extension agents work under the ministry of agriculture either at the state or federal level and Agricultural Development Program (ADP). Mgbenka and Mbah (2018) also described extension agent as a trained employee who develops and delivers educational programs to assist rural farmers in economic and community development, leadership, agriculture and environment. The rural farmers in this study are small holder farmers who carry out agricultural activities in the villages and are in need of agricultural information from extension agents.

The Nigerian agricultural extension service is bedeviled by several problems as identified by Imoloame and Olarewuju (2014) such as inadequate funding, poor logistic support, and poorly trained personnel at local level, ineffective agricultural research extension linkages, and insufficient agricultural technologies for farmers and disproportionate number of extension agents to farm family ratio. Other observed problems stated by Asikadi, (2010) are poor input supply, lack of clientele participation in program development, irregular policy and program instability. Asikadi, (2010) further attested that to address the above problems, some veritable tools have to be employed such as provision of rural amenity-based infrastructures should be provided to keep the rural areas comfortable for the rural farmers.

Rural amenity-based are facilities provided that focused on developing the rural areas where the extension agents are sent to work with the farmers. In submission of Ndem *et al*. (2020), rural amenities are desirable facilities that are provided in the rural areas to make life comfortable and lively. They identified some of the rural amenities-based infrastructures as; recreational centers, health care services, portable water, civic centers, reliable security network, good road network, sound vehicles, modern markets, standard schools at affordable prices for the children, rural electrification, WIFI for internet connections, computers/laptops, electricity, good road network among other

As it stands, most rural farmers in Delta State still operate at subsistence level with low input and low return from their farms because of dearth in information (Egbe *et al.,* 2022). This signifies that there is a gap between government research stations and rural farmers. This gap could be filled by extension agents, who are the go-between the farmers and the research information institutes. It is against this background that this work was carried out to determine rural amenity-based; a veritable tool to enhance extension agents' effectiveness for food security in Delta State. Specifically, the study determines the provision of electricity in the rural areas to enhance extension agents in delivering information on cassava production to rural farmers and the provision of good road network to enhance extension agents in assisting the rural farmers in marketing of cassava products.

METHODOLOGY

The study was conducted in Delta State. Delta was chosen for the study because it is an agrarian State, dominated with rural farmers who are in need of agricultural information. Survey research design was adopted for the study. Two research questions guided the study. The study was carried out in three senatorial zones in Delta State. The population of the study was 200 comprised of 120 extension agents and 80 agricultural education lecturers in Delta State. The entire population was studied since the population was manageable. Hence, there was no need for any sampling technique.

A questionnaire tagged 'veritable tool to enhance extension agents in delivering information on cassava production to rural farmers questionnaire'' (VTEEADICPRFQ) consisting of 27 items was developed from the literature and used as the instrument for data collection. The scale for questionnaire was: Strongly Agreed (SA)-4, Agreed (A)-3, Disagreed (D)-2, Strongly Disagreed (SD)-1. The questionnaire was face validated by three experts from agricultural Education Department, Federal College of Education (Technical) Asaba, Delta State. The questionnaire was administered to 200 respondents and collected with the help of three research assistants. There was 97% return rate which equated to 193 respondents. Cronbach alpha was used to determine the internal consistency of the questionnaire which yielded a coefficient of 0.77. Mean and Standard deviation was used to answer research questions. The cutoff point of 2.50 was applied in decision making for the research questions thus; any item with a mean value of 2.50 and above was agreed as a veritable tool for enhancing extension agents in delivering information while any item value less than 2.50 was rejected as a veritable tool for enhancing extension agents in delivering information to farmers.

RESULTS

Result in table below revealed that the mean responses range from 2.10 for item 9 to 3.81 for item 7. The respondents agreed to items 1 to 8 but disagreed with item 9. This implies that mean responses in the way provision of electricity listed except electronics using mobile app can enhance extension agents in delivering information on cassava production to farmers for food security in Delta State. The findings of this study showed that extension agents and agricultural education lecturers in Delta State rated all the items in research question 1 above the cut-off point of 2.50. This is an indication that the respondents agreed that charging phones and laptops, using desktop to connect to internet, Ipad/Tablets for getting handy information and making some designs, Electricity helps the extension agents to use power point in making presentations to the rural farmers. Electricity helps the extension agents in using television to show some agricultural activities that can facilitate the learning of the rural farmers, radio for organizing programmes that can reach out to large number of farmers at a time, use electronics to monitor and evaluate farmers using mobile apps. The result agrees with Mgbenka and Mbah, (2018) who identified that rural electrification enhances the extension agents in delivering timely information on cassava production to rural farmers.

Table 1: Mean responses of extension agents and lectures on the ways provision of electricity in the rural areas can enhance extension agents in delivering cassava production information to farmers for food security in Delta State.

S/N	ITEM STATEMENT	MEAN	S.D	RANK
1	Charging phones to stay connected in delivering information information to rural farmers	3.50	0.44	Agreed
2	Charging of Laptops computer in making graphic work with the production of images in educating the rural farmers	3.55	0.67	Agreed
3	Desktop for connecting to internet in searching relevant agricultural information	3.67	0.68	Agreed
4	Ipad/Tablets for getting handy information and making some designs	3.56	0.65	Agreed
5	Electricity helps the extension agents to use power point in making presentations to the rural farmers.	3.64	0.54	Agreed
6	Electricity helps the extension agents in using television to show some agricultural activities that can facilitate the learning of the rural farmers.	3.68	0.59	Agreed
7	Radio for organizing programmes that can reach out to large number of farmers at a time	3.81	0.43	Agreed
8	Electricity helps the extension agents to plug the digital camera to show pictures and videos that can enhance the understanding of the rural farmers during training	3.65	0.47	Agreed
9	Use electronics to monitor and evaluate farmers using mobile apps	2.10	0.49	Disagreed
	Grand mean	**3.46**	**Agreed**	

SD = Standard deviation

Result in Table 2 below revealed that the mean responses range from 2.40 for item 7 to 3.81 for item 4. The respondents agreed to items 1 to 6 and 8 but disagreed with item 7. The grand mean of 3.50 indicates that construction of good road network in the rural areas can enhance extension agents in delivering information on cassava production to the rural farmers.The implication is that the respondents agreed that Quick access to farm inputs, Increase in the total area cultivated by the cassava farmers, Creating an enabling environment to promote agricultural production and alleviates poverty, Facilitation of technology transfer and adoption of best practices in planting cassava, Increasing the quick access to demonstration farms scattered around the community, Increase in the number of demonstration plots that where they teach the rural farmers new innovations, and increase in the number of extension services which facilitate the introduction of more efficient cassava farming system. The result is in agreement with Ndem *et al*., (2020), who reported that construction of good road network in the rural areas is one of the rural amenities lead to quick delivery of agricultural information and multiple demonstration plots by extension agents.

Table 2: Mean responses of respondents on the ways on the ways construction of good road network in the rural areas enhances extension agents in delivering information on cassava production to the rural farmers.

S/N	ITEM STATEMENT	Mean	SD	Rank
1	Quick access to farm inputs	3.54	0.59	Agreed
2	Increase in the total area cultivated by the cassava farmers	3.56	0.53	Agreed
3	Creating an enabling environment to promote agricultural production and alleviates poverty	3.67	0.65	Agreed
4	Facilitation of technology transfer and adoption of best practices in planting cassava.	3.81	0.57	Agreed
5	Increasing the quick access to demonstration farms scattered around the community.	3.65	0.78	Agreed
6	Increase in the number of demonstration plots that where they teach the rural farmers new innovations.	3.68	0.81	Agreed
7	Facilitating the mobilization of the community to address common problems regarding the outbreak of pests and diseases.	2,40	0.79	Disagreed
8	Increase in the number of extension services which facilitate the introduction of more efficient cassava farming system.	3.66	0.76	Agreed
	Grand mean	**3.50**	**0.08**	**Agreed**

S.D = Standard deviation

CONCLUSION

There is dearth of agricultural information to rural farmers in Delta State. It was discovered in this study that all the veritable tools if provided could enhance extension agents' effectiveness in closing the gap in information delivery to rural farmers. From the findings it was concluded that charging phones to stay connected in delivering information to rural farmers, radio for organizing programmes that can reach out to large number of farmers at a time, facilitating the mobilization of the community to address common problems regarding the outbreak of pests and diseases and increase in the number of extension services which facilitate the introduction of more efficient cassava farming system and creating an enabling environment to promote agricultural production and alleviates poverty. Certainly, the effectiveness of extension agents in information delivery to rural farmers, will lead to substantial increase in cassava production and ensure food security.

RECOMMENDATIONS

Based on the findings and conclusion of this study, the following recommendations were made:

1. Delta State government through the ministry agriculture should provide electricity to all rural areas to make the place lively.
2. The local government through the town unions and elites should among other projects construct good road network at the rural areas to enhance extension agents in delivering quick innovative information to rural farmers.

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AN APPROACH TO ENHANCING FOOD SECURITY IN NIGERIA: A REVIEW

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ABSTRACT

This paper attempted to look at the approach to enhancing food security in Nigeria. Food security is an issue that needs the attention of stakeholders who are the leaders of this great Country Nigeria at various levels. From the Federal down to the local government rural farmers need support to boost and increase food production as well as the security and the safety of their lives. This is necessary because many rural farmers especially in the Northern parts of Nigeria are migrating to urban areas for safety due to the crisis going on in the country, which has left many homeless and jobless due to constant attacks. Crisis of any kind affect food supply, which may eventually lead to food insecurity. Insecurity of any kind could hinder or slow down growth and development of an individual or nation. Having enough food for all is what is needed for growth development in Sub- Sahara Africa and indeed Nigeria.

Keywords: *Food security, enhancing approach, Insecurity.*

INTRODUCTION

The relevance and significance of food to human existence cannot be overemphasized, thus steady food supply gives stability to individuals, families, societies, nations and the world at large. Iweoha *et al*. (2015) opined that food is the most basic need of man. Its adequacy affordability and security have been the pursuit of every community. One of the indices of a Nations development is the level of food and nutrition that is available to its citizenry. The disparity in national development between developed, developing and underdeveloped nations has been linked to the issue of food and security. Food security has to do with having at all times an adequate level of food and food products to meet the increasing consumption demand to mitigate fluctuation in output and price (Idrisa, 2008). In the same vein the World Bank Policy Study (2006) defined food security as access to enough food for active healthy living by all people at all times. On the other hand, food insecurity according to Food and Agricultural Organization (2010) refers to the consequences of inadequate consumption of nutritious food, considering the psychological use of food by the body as being within the domain of nutrition and health. Furthermore, malnourishment also leads to poor health, hence individuals fail to provide for their families. If left unaddressed, hunger will set in motion, and an array of outcomes that perpetuate malnutrition which reduce the ability of adults to work and give birth to healthy children this also will erode children's ability to learn and lead productive healthy and happy lives. This truncation of human development undermines a country's, potentials for economic development for generations to come (Otaha, 2013).

Despite all effort to meet up with food security in Nigeria, this effort has being abused due to the frequent crisis and unrest that has cause setback to agricultural activity, this has contributed negatively in enhancing food security in the states as people run away from homes to save their lives, this is the problem that need to be readdress to enhance food security, hence this study.

RESULTS AND DISCUSSION.

Results for this study were collected from previously established studies published in journals, conferences, textbooks and workshops. This was done to gather related information as a means of enhancing food security in Nigeria and the Sub-Saharan Africa at large.

Causes of Food Insecurity in Nigeria

In recent years, however, most farm lands have been deserted due to some illegal activities in Nigeria such as kidnapping, banditry, robbery and herder's clashes, which have created fear to farmers. If this menace is unchecked, farmers will prefer to stay at home in fear, while hunger and poverty have its way into homes of helpless farmers. Any country that fails to prepare or plan for its future, by making provision for the needed resources, food inclusive for development, that country is bound to remain in perpetual conflict in particular social, emotional as well as economic conflict. The survival and development of any nation in any aspect of life is associated with the strength and ability of that nation to handle issues and challenges with much ease, and this can only be achieved when food is available and accessible not on how much weapons of destruction available. The greatest weapon that has kept and built nations is sufficient food supply. The challenges in Nigeria have affected farm produce as many farmers are chased out of their farm lands; some are forced to relocate to urban areas where they depend on what people can offer them. According to Eme, Onyish Anthony Uche and Uche (2014). From Benue to Taraba, Nasarawa and Plateau in the North Central region and Zamfara and Kaduna States in the North West, clashes between farmers and herdsmen have left in its trail heavy loses of lives and property. These loses of lives have adversely affected farming activities and other related businesses. This has resulted in drastic reduction in farm outputs, a development that has heightened the fear of hunger.

Already most farmers in the affected States have abandoned farms for fear of being attacked by the herdsmen. For the predominantly farming communities of Nasarawa and Taraba States, farming is no longer business as usual. Several farmers have been displaced and dispossessed of their farms by armed men believed to be Fulani herdsmen. In the North West, Katsina, Sokoto and Zamfara States have been experiencing such activities of bandits, which have crippled farming activities in some parts of these states (FEWS NET, 2019).

Effects of Food Insecurity

Without food, lives will be wasted that is why many developing countries (Nigeria inclusive) face malnutrition problems such as Protein Energy Malnutrition (PEM). Apart from banditry, farmers also face challenges of drought, flood and even political instability. The growth and development of any country is tied to steady food supply. Food security remains an elementary and basic requisite for national development and as such, has been used by different people to convey different thoughts. The duo further reiterated that the rapid annual population growth in Nigeria, particularly in the last decades has seen food insecurity spiraling to become the norm in many homes, a trend which has escalated the intensity of poverty and lack of access to food. They also submitted that there is interplay of population growth, bad policies of government, lack of infrastructural development, rural-urban drift, and lack of incentives, poverty of peasants as well as undercapitalization to fuel the fangs of food insecurity in Nigeria (Igbinedion and Aihie, 2015). On the Nigeria food security outlook of famine, Early Warning system Network (2013) reported that Nigeria witnessed an unprecedented flooding cases between July and October, 2012 as a result of persistent heavy rainfall coupled with the release of water from several dams. These incidences caused the displacements of about 2.8 million people. Several months later, the affected households could still not fully recover their livelihoods. High level of food insecurity soon ensured in the regions due to low food stocks and high food prices. However, most households have started returning to their homes to rebuild their livelihoods (FEWSNET, 2013). The paper therefore examined an approach to enhancing food security in Nigeria.

Sustainability Development in Ensuring Food Security

In rethinking the approach for sustainable development in ensuring food security in Nigeria, the potentials of agriculture can be enhanced through institutional frameworks, governance and accountability. From the empirical study of Osabohien *et al.* (2018a) employing the Auto-regressive Distributed Lag (ARDL) technique in examining the role of institutional framework on food security, pointed out that institutional framework in Nigeria exerts a negative effect on food security, due to weak institutional quality in Nigeria. According to Osabohien *et al*. (2018b) the Nigerian agricultural sector remains an important sector of the economy, owning to the fact that the sector employs approximately 75% of the total work force, especially in the rural communities where most of the farmers earn their livelihood.

A study by Munene *et al.* (2018) employed the adaptive governance approach and noted the need to redirect strategies to achieve sustainable development. This would be more effective through the implementation of the framework requiring non-traditional management and governance approaches for substantial reduction of food waste. It was noted that Adaptive governance (AG) has been known to be the medium to drastically change the link between development and disaster risk, with potentially far-reaching implications for policy and practice to ensure food security. Osabuohien *et al.* (2018) used qualitative method with focus group discussion to examine how local institutions contribute to food (rice) production in Ogun State, Nigeria where they pointed out that local institutions play a key role in food production. In the study by Herbel *et al.* (2012), it was shown that achieving food security and the enhancement of dietary level is at the heart of the Sustainable Development Goals (SDGs). In line with that, Sidibé *et al.* (2018) noted that achieving food security can be done through the enforcement of rules and laws designed at the national level which remains one of the central institutional mechanisms for efficient multi-scale governance in most countries.

Enlightenment to Stakeholders by Policy Makers to Improved Food Security

According to Osabohien *et al.* (2019) policymakers are increasingly enlightened on the food security perspective, which has over the years reflected poorly in institutional terms. This study fills this gap by addressing the question as to what forms of accountability and governance is more appropriate to govern food systems in a more holistic way to achieve sustainable development goals (SDGs) by year 2030. In Africa, food security in relatively is high on the policy agenda of governmental authorities all over the globe (Candel, 2014). 'Food security governance' relates to the 'formal and informal' rules and processes through which interests are expressed, and decisions which are germane to food security in a country are prepared, implemented and enforced on behalf of members of society.Studies by Rodrik (2010), Osabuohien *et al.* (2018) to achieve food security reveal the need for equal opportunity in resource allocation and the delivery of services; coherent and coordinated policies, institutions, and actions. This means that the challenge for policymakers interested in addressing the key policy issues are to redesign strategies that allow countries to have a stable and affordable food supply that is equitably distributed as household food insecurity continues to be widespread with strong inequities across and within countries governance and strategies. Given the pathetic economic situation in some critical parts of the country, for example; the north east (Scribner, 2017; Ajayi and Adenegan, 2018), where starvation has been prevalent due to insurgency, the use of the right approach to addressing the national challenge of food insecurity, based on a platform of accountability, have remained a maximum requirement for achieving the right results of this subject area.

CONCLUSION

The study revealed that food security Can only be enhanced if government allocate equal resources and delivery of services and enforcement of rules and laws designed at the national level.Food security can also be enhanced by sustainable development and the strategies to reduce food waste.

RECOMMENDATIONS

Food security can be improved in the following ways:

1. Reducing food waste and food loss. ...
2. Improving infrastructure. ...
3. Promoting fair trading practices. ...
4. Paying attention to diversification. ...
5. Reducing the yield gap. ...
6. Combating climate change. ...
7. Addressing the indirect causes of food insecurity

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ANALYSIS OF VARIETY DISSEMINATION, PREFERRED TRAITS AND MARKET SEGMENTS IN TWO MAJOR SWEETPOTATO PRODUCING STATES IN NIGERIA

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ABSTRACT
The study was conducted in Ebonyi and Nasarawa States with the aim to identify preferred traits and market segments for the end users and for future Breeding programme activities. A multistage sampling was used to select 40 actors from each state for the group discussion. Data collected with the use of ODK (Open Data Kit) includes: current sweetpotato varieties being cultivated, sweetpotato preferred traits, preferred traits in future variety and sweetpotato market segment and were analyzed descriptively. Results indicated that the most important traits for future adoption of sweetpotato variety were high yield, big storage roots, early maturity, pest-free, white fleshed storage roots and white skin for market demand due to external appearance. Considering end users preferences and constraints, breeding programmes should involve the farmers, marketers, food processors and consumers to meet their need for easy adoption of new released varieties.
Keywords: *Adoption, Preferred traits, Stakeholders, Value chain and Breeding*

INTRODUCTION
It has been suggested that before commencing a breeding programme, there is need to find out what are farmers' priority needs in a variety, the farmers' preferences and practices (Chambers, 1997). The only effective way to get information and the opinion of stakeholders on the sweetpotato production and constraints to increase the crops utilization is by Participatory Rural Appraisal (PRA) (Gasura *et al*., 2008; Gibson *et al*., 2007). This is a research tool that involves community members. The methods include interviewing farmers with the use of matrix scoring and listed traits are paired and ranked (traits compared pair by pair). It also involved focused group discussions (FGD) which may involve the use of pictures and cards, questionnaire surveys and review of relevant articles (Fuglie, 2007; Mmasa *et al*. 2012). This was the case for selecting for traits for breeding including sweetpotato breeding.

The sweetpotato crop feeds over 100 million people in the poor communities in Africa, and therefore plays a significant role in human nutrition and livelihood. The crop is a cheap source of protein (2-8%), carbohydrate (32%), fibre (56%) and micronutrients, especially iron (70 mg/kg), zinc (33 mg/kg), and vitamin A that enhance normal body and mental growth and development. The mineral iron, provide 127% and 80% of daily estimated average requirements of children and women respectively. The roots can also be processed into flour for bread making, starch for noodles and as raw material for industrial starch and alcohol (Ukom *et al*., 2009). Tewe *et al*. (2000), reported that sweetpotato flour is utilized in sweetening local beverages like Kunu-zaki, burukutu, and for fortifying baby foods and fufu/pounded yam in Nigeria. The leaves are used as vegetables in yam and cocoyam porridge and are rich in proteins, vitamins and various minerals. Sweetpotato has varieties of varying colours including white, yellow orange and purple fleshed.

However, these existing varieties are degenerating as a result of pests and diseases, climatic changes and customer's demand. The natural way of developing new varieties is by hybridization. Hybridization is one of the ways to generate variability in sweetpotatoes and as noted by Nwankwo *et al*., (2011), it is one of the revolutionary tools which tend to create genetic novelty for selection. Considering end users preferences and constraints, breeding programmes should involve the client to meet their need for easy adoption of new released varieties. This paper was to provide a baseline for the development of traits preferred by end users with the following objectives: to identify what varieties the end users are currently using, to identify preferred traits by end users and constraints hindering sweetpotato production, to identify market segments for end users in order to increase sweetpotato production and utilization and to establish a database of preferred traits by sweetpotato end users for consideration in future Breeding program activities.

MATERIALS AND METHODS

The study area: The study was conducted in Nasarawa (North Central) and Ebonyi (Southeastern part of the country) States.

Nature of respondents: Participants were selected from sweetpotato stakeholders, who were made up of male and female farmers, marketers, consumers and food processors. These made up the Focus Discussion Group (FDG) in each State. The discussion was conducted using questionnaire, participatory methods and data were collected on variety dissemination, market segments and preferred traits of the sweetpotato.

Sampling procedure: A multistage purposive and random sampling was used. Firstly, the study purposively selected one agricultural zone with high intensive production of sweetpotato. Secondly, the study purposively selected one LGA with intensive production. In the third stage, two communities were selected randomly from the Local Government Area giving a sample of 4 communities – 2 from each State. In the last stage, 20 (10 males and 10 females) sweetpotato stakeholders were systematically selected giving a total of 80 respondents for the study – 40 from each state.

Data collection for SSQ: Data was collected using ODK, established during Participatory Rural Appraisal (PRA). Administration of a Semi-Structured Questionnaire was addressed through PRA (Gibson *et al*., 2007; Gasura *et al*., 2008).

FOCUS GROUP DISCUSSION (FGD)

Nature of respondents: FGD was established in each State. A total of 40 persons attended the meeting at the Ministry of Agriculture of each State. (Total of 80 participants from the two States) made up of: farmers, marketers, consumers and agricultural extension agents were the nature of the participants that made up the FGD in the two States. The 20 males and 20 females in each State regardless of heads of household and discussion were not based on sexes.

Data analysis: The data collected were analyzed descriptively using percentage, mean, standard deviation and frequency.

RESULTS AND DISCUSSION

Rank and trait preference of sweetpotato

The results in Table 1 showed the participants rank of sweetpotato among roots and tuber crops in the states, and preferred traits. The FGD in Ebonyi State ranked sweetpotato among the roots and tuber crops as third preferred crop after yam, cassava and after cocoyam; whereas in Nasarawa State sweetpotato was ranked 2nd after yam and after cassava and cocoyam.

Table 1: Participants Rank of sweetpotato among roots and tuber crops in the states, an preferred Traits

Responses	Ebonyi	Position	Nassarawa	Position
The rank of sweetpotato among roots and tuber crops in the states	Yam, Cassava, Sweetpotato, Cocoyam	3rd	Yam Sweetpotato, Cassava, Cocoyam	2nd
6 traits preferred in descending order	**High yield**, White fleshed, Big storage root, white skin, Extra-early maturity, High dry matter		**High yield**, Big storage root, White fleshed, No pests, Moderate sugar, White skin	

Source: Sweetpotato field survey in Ebonyi and Nasarawa States, 2022-2023

The study also highlighted the mention six traits preferred in a future variety in descending order as; high yield, white fleshed, big storage root, white skin, extra-early maturity and high dry matter while the group in Nasarawa State mentioned high yield, big storage root, white fleshed, no pests, moderate sugar and white skin. This showed common traits of high yield and big storage roots. Generally, every farmer requires high yielding varieties that would enhance his/her income generation. Big storage roots are a function of high yield. The mention of white skin, and white flesh colour in both States indicated that the market. Interestingly, Orange fleshed sweetpotato colour was not mentioned in the study areas – calling for new area of research and promotion.

Number of participants, Varietal status and Most preferred varieties

The number of participants, varietal status and most preferred varieties are presented in Table 2. he results in Table 1 indicated that 90% of the participants in the FGD cultivated landraces in Ebonyi State while 10% of the participants cultivated improved varieties. In Nasarawa State, the 95% of the participants in the FGD cultivated landraces while 5% cultivated improved varieties. This indicated the availability and possibly affordability and choice of landraces over improved varieties in both study areas.

Table 2: Number of participants, Varietal status and Most preferred varieties (FGD)

Responses	Ebonyi State		Nasarawa State	
	Freq. (40)	%	Freq. (40)	%
planted landraces	36	90.0	38	95.0
plant improved varieties	4	10.0	2	5.0
Do you regard sweetpotato as food and cash crop	40	100.0	40	100.0
Do you regard sweetpotato as food crop only	0	0.0	0	0.0
Do you regard sweetpotato as cash crop only	0	0.0	0	0.0
preferred Landraces	34	85	35	87.5
preferred improved varieties	6	15	5	12.5
Received varieties from Agric Extension Agents	3	7.5	6	15
Not received varieties from Research Institute	37	92.5	34	85.0
Not received training from research Institute	40	100.0	40	100.0

Source: Sweetpotato field survey in Ebonyi and Nasarawa States, 2022-2023

This was clearer as about 85% and 87.5% of the respondents in Ebonyi and Nasarawa State respectively reported that the landraces were their most preferred varieties than 15% and 12.5% who preferred improved varieties. The landraces being cultivated and preferred possess white skin and white fleshed storage roots. However, this may be that the traits appeal to the eyes and command high market price. However, the 7.5% and 15% from Ebonyi and Nasarawa States that cultivate improved varieties claimed that they obtained their seeds (planting material) it from the research Institute and Agricultural Extension Officers within their State. The reason behind the low adoption of some of these varieties as observed during the FGD was low dry matter as t complained that they could not pound the improved varieties as *fufu* because it of its softness. Hence, this call for breeding for end-users preferred varieties for ease of adoption and usage. The study also showed that all (100% each) the respondents in both States agreed that sweetpotato is both food and cash crop. This may be the reason why almost all the farmers cultivate sweetpotato for food since it is their staple food and as well cash crop for income generation. About 92.5% of the participants in Ebonyi State and 85% in Nasarawa State reported that they have not received any improved varieties from the Research Institute in the country, while 7.5% and 15% respectively do received. The high percentage of those who do not received improved varieties through Agricultural extension Agents was an indication of poor communication gap of Agricultural Extension Agents and Research Institute. This was also in the case of percentage (100% each for both states) that never received training from Research Institute indicating very poor circulation of information on sweetpotato technologies and as well confirmed the findings of poor use of improved varieties.

Marketing of sweetpotato roots and foliage

The results in Table 3 presented the respondents view on the marketing of sweetpotato root and foliage in both States under study. The results showed that about 37.5% and 50% (Ebonyi) and 25.0% and 60% (Nasarawa) of participants do not sale storage roots and fodder to livestock farmers respectively.

Table 3: Marketing of sweetpotato roots and foliage

	Ebonyi state		**Nasarawa State**	
Responses	**Freq(40)**	**%**	**Freq(40)**	**%**
Not marketing storage roots to livestock farmers	15	37.5	10	25.0
Sold fodder to livestock farmers	5	12..5	6	15.0
Not selling roots and fodder to livestock farmers	20	50	24	60.0
Not selling leaves as vegetable for human consumption	0	0	0	0

Source: Sweetpotato field survey in Ebonyi and Nasarawa States, 2022-2023

However, the discussion revealed that the livestock farmers such as pigs, sheep and goats purchase storage root (especially un-marketable roots) of sweetpotato for fattening their animals. Also 12.5% and 15 % of the participant in Ebonyi State and Nasarawa State respectively sold sweetpotato leaves as fodder to livestock farmers. This shows that even the leaves of sweetpotato could be used for income generation although many do not concept the idea (sweetpotato livestock fodder business) as a business. However despite the fact that the leaves of sweetpotato are rich in protein and vitamins, there was no business as to commercialize it as vegetable for human consumption. This was against a prior expectation as none (0.0% each) of the participants reported selling sweetpotato leaves as vegetable for human consumption probably due to the unawareness of sweetpotato leave diet, hence calling for exploitation and awareness.

Preference for Local Varieties

The reasons why the Focus Group preferred the local varieties are presented in Table 4.

Table 4: Preference for local Varieties

Responses	Ebonyi State Frequency(40)	%	Nasarawa State Frequency(40)	%
Variety known for long time	18	45	17	42.5
Possess white flesh and white skin colour	7	17.5	9	22.5
Local varieties can be harvested any time	6	15.0	4	10.0
Good cooking quality	2	5.0	3	7.5
Can be pounded for fufu	4	10.0	3	7.5
Yield	3	7.5	4	10.0

Source: Field survey, 2022-2023

The study showed that the stakeholder preferred their local varieties because of it is known for a long time (45% and 42.5%); possess white flesh and skin colour (17.50% and 22.50%), harvested any tie (15.0% and 10.0%), can be pounded as *fufu* (10.00% and 7.50%) and yield (7.5% and 10.0%). From the discussion, it was observed that some of them have seen the improved varieties but to change to new variety or varieties not known to their forefathers had been difficult, it seems as if they were betraying their forefathers' crop. Other reasons given for clinging to the local varieties was artistic. By this assertion, they acknowledged that local varieties were low yielding. Low yield is a bad trait in any crop. Farmers do not want any low yielding variety for food and income generation.

Traits preferred in future sweetpotato varieties

The traits the focus group would prefer in future sweetpotato variety are presented in the Table 5.

Table 5: Traits preferred in future sweetpotato varieties

Traits	Ebonyi state Frequency	%	Nasarawa State Frequency	%
High yield	9	22.5	8	20.0
White skin colour	6	15.0	5	12.5
white fleshed storage root colour	2	5.0	3	7.5
Big storage root	3	7.5	6	15.0
erect varieties	0	0	0	0
high dry matter	5	12.5	6	15.0
resistant to pests	4	10.0	1	2.5
moderate sugar	0	0	4	10.0
low sugar	5	12.5	0	0
drought tolerant	6	15.0	5	12.5
low fibre	0	0	2	5.0

Source: Sweetpotato field survey in Ebonyi and Nasarawa States, 2022-2023

The study showed that about 22.5% and 20% of the participants in Ebonyi and Nasarawa States reported that they would like their future sweetpotato varieties to be high yielding. This was followed by white skin colour and drought tolerant (15.5% and 12.5% each), high dry matter and (12.5% and 15%), low sugar (12.5% for Ebonyi), and resistant to pest (10.0% and 2.5%) for Ebonyi and Nasarawa States respectively. However, as rainfall is becoming irregular and unpredictable, farmers tend to go for future varieties to be drought tolerant. Dry matter content is a component of yield of a variety, they would prefer their future varieties to possess high dry matter in the storage roots. Fibre content in the storage roots reduces flour yield, however, 5% of those that participated in Nasarawa State will prefer future sweetpotato varieties to contain low fibre in the storage roots. In the next generation sweetpotato varieties, 12.5% of the focus group participants in Ebonyi State and 10% that participated in Nasarawa State want their new varieties to be of low sugar and moderate sugar respectively in their storage roots. No future sweetpotato varieties would contain all these traits in one variety only a combination of traits for a variety for various end–users.

CONCLUSION

The most important traits for adoption of sweetpotato variety are high yield, big storage roots, early maturity, pest-free, white fleshed storage roots and white skin for market demand due to external appearance. Others include: taste, nutritive value and multipurpose utilization, considering end users preferences and constraints, breeding programmes should involve the farmers, Marketers, food processors and consumers to meet their need for easy adoption of new released variety. Based on the focus group discussion, there is need for training of the sweetpotato stakeholders on sweetpotato production in some related areas. As most of the farmers cultivate landraces indicating that the very few released varieties were not in the hands of the stakeholders. The study therefore call for urgent need for awareness and sensitization of the farmers, Marketers, food processors and consumers of the importance and benefits of these sweetpotato varieties released by the NRCRI for easy adoption.

Many of the traits mentioned as constraints to all the stakeholders need to be addressed by breeding team while others were of agronomy and post-harvest handling.

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FACTORS INFLUENCING BIODIVERSITY LOSSES AMONG RURAL HOUSEHOLDS IN KOGI STATE NIGERIA

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ABSTRACT
The study examined factors influencing biodiversity losses among rural households in Kogi State. A multistage sampling technique was adopted and a sample size of 200 respondents drawn from six Local Government Areas spread across the three agricultural zones of the state. Data were collected with the aid of structured questionnaire and were analysed using percentages, means and Varimax rotated factor matrix. The results elucidated that majority of the households were headed by males. The average age of the respondents was 51 years with average education attainment of 6 years with an annual income of 252,000 naira. The household and farm sizes were 14 persons and 2.7 hectares respectively. The results also elucidate that cutting down of trees (0.931), bush burning (0.878), increase in population (0.745), grazing (0.760), erecting of buildings (0.552) hunting activities (0.530), destruction of habitats (0.520), mining (0.511) were variables loaded high under factor 1 (Socio-economic constraints). Furthermore climate change (0.896), erosion (0.867), over flowing of streams (0.762), natural disaster (0.752), pollution (0.531) and drying up of water bodies (0.412) were significant under factor 2 (geographical constraints). The study recommended policy measures that would help improve and integrate the livelihood of rural communities and reduce their overdependence on the natural environment in order to promote sustainable environment.
***Keywords:** Biodiversity Losses, Rural Households, Kogi state*

INTRODUCTION
Biodiversity has been and will continue to be an important part of agricultural practices worldwide. Biodiversity is important because it provides man with many resources. It plays a crucial role in maintaining ecosystem functions and services such as pollination, pest control, and soil formation (Abere and Opara, 2018). Biodiversity in Nigeria is seriously under the threat of extinction from human activities, climate change, economic development, land use changes from agriculture, invasive species and pollution, crude oil exploration and exploitation, canalization that has threatened mainly the mangroves, deforestation, desert encroachment, over hunting, land use, road and residential buildings construction (Anwadike, 2020). The growing concerns over the increasing rate of biodiversity loss globally have sparked extensive research into various ways by which biodiversity composition can be preserved (Bellard *et al.*, 2012). Loss in biodiversity due to human activities have been rapid recently than at any time in human history and the factors responsible for biodiversity loss are either steady, show no evidence of declining over time or increasing in intensity (Millennium Ecosystem Assessment (MEA), 2005; David (2011)). Oribhabor (2016) stated that species are becoming extinct at the fastest rate known in geological history due to human and industrial activities which continue to result in the discharge of various pollutants into the environment threatening the health of the population and damaging the quality of the environment. Consequently, biodiversity losses alter ecosystem processes, undermine ecosystem functioning and weakens the resilience of ecosystems to environmental change and compromise their ability to continuously supply ecosystem services, loss of livelihoods, increased contact with diseases and reduced food security. In spite of the dare consequences of biodiversity loss on human existence, there are inadequate empirical evidences on knowledge about factors that influence biodiversity loss in the study area. Thus, there is urgent need to undertake a study of this nature to provide empirical evidence for policy direction.

METHODOLOGY

The study was conducted in Kogi State, Nigeria. The population of this study consisted of all heads of rural households in the four agricultural zones in Kogi State namely: namely Aiyetoro-Gbede (Zone A), Anyigba (Zone B), Koton karfe (Zone C) and Aloma (Zone D). A Multi-stage sampling procedure was used for data collection. In the first stage, three out of the four agricultural zones in the state were randomly selected namely: The selected zones were Anyigba, Aloma and Koton karfe. Two (2) Local Government Areas (LGAs) were purposively selected from each of the three agricultural zones due to abundant agricultural activities carried out in the zones resulting in a total of six (6) LGAs in the second stage. The selected LGAs are Ajaokuta, Ankpa, Dekina, Ofu, Olamaboro, and Lokoja. In the third stage, two rural communities were randomly selected from each of the LGAs using simple random sampling techniques to get six communities. Finally, a sampling frame was developed from the population of households from the selected communities which was used to obtain the total sample size of 200 respondents for the study, using 10% proportional allocations. Data were collected with the aid of structured questionnaire. Descriptive statistics was used to achieve objective one while factor analysis was used to achieve objective two. Variables for this study were measured as follows: age (Years), Sex (Male=1, otherwise =0), Marital status: (married = 1, otherwise = 0), Household size (number), Income (naira), level of education (years spent in school), Farm size (hectares), primary occupation (farming=1, otherwise=0). A Four (4) point Likert-type scale of: strongly agree (4), agree (3), disagree (2) and strongly disagree (1) was used to determine the perception of the respondents on the factors influencing biodiversity losses in the study area.

RESULTS AND DISCUSSION

The result in Table 1 shows the distribution of the respondents according to socio-economic characteristics. The result indicates that one hundred and fifty nine (159) representing 79.5 were male headed.

Table 1: Distribution of respondents according to socio-economic characteristics (n=200)

Parameters	Frequency	Percentage	Mean
Sex			
Male	159	79.5	
Female	41	20.5	
Age (Years)			
31-40	21	10.5	
41-50	73	36.5	
51-60	73	36.5	51
≥61	33	16.5	
Marital status			
Married	180	90.5	
Others	20	9.5	
Level of education			
Non-formal	48	24	
Primary education	65	32.5	6
Secondary education	63	31.5	
Tertiary education	24	12	
Household size			
1-5	15	7.5	
6-10	102	51.0	
11-15	67	33.5	14
16-20	16	8	
Farming Experience (Years)			
1-10	19	9.5	
11-20	91	45.5	18
≥21	90	45.0	
Farm size (Hectare)			
1-2	88	44	
3-4	86	43	2.7
≥5	23	13	
Farming Occupation			
Farming	196	98.0	
Others	4	2.0	
Annual income (Naira)			
≤100,000	18	9.0	
100,001-200,000	66	33.0	
200,001-300,000	73	36.5	252,000

300,001-400,000	35	17.5
≥400,001	8	4.0

Source: computed from field data (2023)

The average age of respondent in the study area is 51 years with average education of 6 years. This suggests that the average household head in the study area barely completed primary education. The average household size in the study is 14 persons. Large family members are considered important asset as source of farm labour.

The average farming experience of respondents is 18 years with average farm size of 2.7 hectares with an average annual income of 252,000 naira. This indicates that an average respondent is a peasant barely earning to survive. This situation is worrisome and could lead to more dependency on nature. The result in Table 2 shows varimax rotated factors constraining biodiversity in the study area as perceived by the respondents. Based on scree plot and total variance explained, two (2) factors were extracted and retained for naming and interpretation of constraints to biodiversity. In this wise, clustered variables in the rotated factor matrix, factor 1 and 2 were named socio-economic constraints and geographical constraints respectively. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy result was 0.806 above the cut-off of 0.50 and above (Yong and Pearce, 2013). The variables that loaded high under factor 1 (Socio-economic constraints) were cutting down of trees (0.931), bush burning (0.878), increase in population (0.745), grazing (0.760), erecting og buildings (0.552), hunting activities (0.530), destruction of habitats (0.520), mining (0.511). The high factor loadings illustrate how closely the variables are to the factor (socio-economic). This result collaborates in part with the findings of Asthana and Asthana (2012), Aguoru and Audu (2012).

Table 2: Varimax rotated factor matrix for factors constraining Biodiversity in the study area (n=200)

Variable	Factor	
	1	2
Bush burning	.878**	.302
Erosion	.316	.867**
Increase in population	.745**	.351
Cutting of trees	.931**	-.262
Grazing	.760**	-.326
Hunting activities	.530**	.321
Erecting buildings	.552**	.254
Over flowing streams	.073	.762**
Poor income	.502**	.279
Climate change	-.310	.896**
Extraction of herds	.325	.221
Natural disaster	-.204	.752**
Destruction of habitats	.520**	.319
Pollution	.382	.531**
Bandits/militant activities	.500**	.023
Mining	.511**	.032
Drying of water bodies	.034	.512**

Source: Computed from field data (2023)
** factor loadings of 0.50 and above are significant

The variables which loaded high in the factor (geographical constraints) included: climate change (0.896), erosion (0.867), over flowing of streams (0.762), natural disaster (0.752), pollution (0.531) and drying up of water bodies (0.412). This result collaborates with finding of Muluneh (2021). The geographical constraints have both direct and indirect effects on biodiversity. The direct effects can be seen in terms high temperatures increasing the frequency and intensity of fire outbreaks and droughts. The indirect effect can be seen as how it can alter the cultural, social and economic landscape of human activities that affect biodiversity. The cumulative effects are extinction of some species, migration, disease outbreak and low agricultural yield. For instance, air pollution is harmful to humans and other living things. Climate change is known to be responsible global warming resulting in rising earth's average temperature causing large scale wildfire outbreaks seen in Turkey, Greece, Italy, Portugal, Cyprus, Algeria and Tunisia.

CONCLUSION AND RECOMMENDATIONS

The study concludes that the major factors influencing biodiversity losses in the study area are cutting down of trees, bush burning, increase in population, grazing, erecting of buildings, hunting activities, destruction of habitats, mining. Other factors that have significant effects on biodiversity include climate change, erosion, over flowing of streams, natural disaster, pollution, drying up of water bodies. The average rural households are largely peasants and their livelihoods depend largely on exploitation of the natural resources which in turns depleting the biodiversity. Based on these findings, the following recommendations are made:

i. Designing integrated crop-livestock-fisheries systems for the recycling of nutrients among the farm components;
ii. Setting up agro-forestry system to deliver soil retention, water and air purification services;
iii. Provision of social amenities in the rural communities in order to improve the livelihood of the rural communities.

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CASSAVA PRODUCTION GROWTH RATE IN NIGERIA AND ITS DOUBLING TIME

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ABSTRACT
The study assessed the growth rate of cassava production and the doubling time of cassava production between 1961 and 2014 in relation to Structural Adjustment Programme (S.A.P.) and Agricultural Transformation Agenda (A.T.A.) policies during the period under study. Pre-SAP period and post-SAP periods were also assessed. The data were sourced from the Food and Agricultural Organisation (1961-2014). Exponential functions as well as the quadratic function in trend variables were used. The result shows that the mean growth rate of cassava in hectares was 8.3%, negative yield of -2.4% and a 7.6% growth rate of cassava output translating into a doubling time of 8 years for cassava hectarage, -23years for yield and 7 years for output. The increase in output might be a result of the expansion of hectarage under cultivation. It was observed that before the introduction of the Structural Adjustment Programme (SAP), the hectarage under cultivation increased by 1.8%, eventually leading to an increase in yield by 0.2% and output by 2.0%. The result under the SAP period shows the growth rate of hectarage, yield, and output to be 16%, -1.0%, and 0.0% respectively. However, there was an improvement in the growth rate of the hectarage, yield, and output after the SAP period, the growth rate of cassava hectarage increased by 2.0%, yield increased by 0.1%, and output increased by 27.2%. The result of the study under the ATA period shows a progressive growth rate of hectarage and output but with a declining rate of growth of yield. Hectarage grew by 18.4%, while yield decreased by -12.0% and output increased by 5%. The declining yield may be due to the non-adoption of modern technology and the conservative nature of the farmers. The study also observed that the introduction of S.A.P and A.T.A. does not appreciably improve the acceleration of the growth rate of cassava production as the doubling time is more of stagnation and deceleration. It was recommended that only technologically driven agricultural policies that will increase production and sustainability be introduced.

INTRODUCTION
Nigeria is the largest producer of cassava in the World with an annual estimate of 60.001 million metric tons, 7.737 million hectares cultivated, and a yield of 77,543 kg/ha, (Food and Agricultural Organization Statistical Database (FAOSTAT, 2021). The country has consistently been ranked as the world's largest producer of cassava since 2005, (FAO, 2012). Global production of cassava amounted to about 278 million metric tons in 2018 out of which Africa's share was put at about 61% (FAOSTAT, 2020). In the same period, Nigeria's production alone increased from 18% (about 42.5 million metric tons) in 2010 to 21.5% (about 59.8 million metric tons) in 2018. FAO projects that by the year 2025, about 62% of global cassava production will be from sub-Saharan Africa (FAOSTAT, 2020).
This development has been attributed to the significant advances made in cassava variety improvement in Nigeria by the International Institutes for Tropical Agriculture (IITA), National Root Crops Research Institutes (NRCRI), Umudike in collaboration with the National Co-ordinated Research Programme (NCRP) on cassava Eke-okoro, and Njoku, (2012). Nigeria Presidential Initiative on Cassava launched in 2003 brought cassava and its potential to the national limelight. The Initiative has a goal of promoting cassava as a viable foreign exchange earner for Nigeria, and also developing the cassava production system in order to sustain the national demand. Another way to increase production is to plant improved varieties that are proven to be disease-tolerant and higher yielding (Ogunyinka and Adebayo, 2020). Another recent government action on cassava production was the federal government's Agricultural Transformation Agenda (ATA). The transformation focuses on the cassava value chain with the production of High Quality of Cassava Flour (HQCF) and making it mandatory for the replacement of

up to 10% wheat flour in bread with cassava, (Asanke-pok, 2013). As part of its effort to develop a vibrant cassava market locally and internationally, the government designed a cassava master plan in 2005 thereby encouraging large production of cassava in the country.

In Africa, cassava is an important staple crop particularly in the tropical countries as the crop has a high potential of feeding rapidly increasing population and is generally more affordable if compared to other staples. In Nigeria, it is the third most consumed crop in the country (FAOSTAT, 2012) after Sorghum and millet, followed by rice, yam and maize. Akinpelu *et al.* (2011) mentioned that the consumption of cassava for poor household in urban areas has double that of non-poor households while in rural areas, the consumption of cassava by poor households has triple that of non-poor households. In Nigeria, cassava is consumed in all regions of the country. Although cassava is rich in carbohydrates, it is very poor in protein and vitamins and as such, several projects are underway to improve the nutrition potential of cassava (via the introduction of Vitamins A) so as to make the crop more suitable for combating hunger and food security issues. The majority (88%) of cassava produced in Africa is used for human food, with over 50% used in the form of processed products (Oyewole and Eforuoku, 2019). Although the crop is considered a staple in many countries, this situation is changing in some countries where cassava is now an industrial and cash crop (Reincke *et al*., 2018).

In Nigeria, cassava products can be grouped into five categories. These are fresh roots, dried roots, pasty products, granulated products, and cassava leaves. A wide array of products can also be processed from cassava. Firstly, the freshly peeled tubers can be either boiled or roasted for food. Boiled tubers can also be further pounded or added to soup and stews. To prevent rapid deterioration, non-food products such as starch and chips (animal feed) can also be produced from the tubers. Chips can also be further grounded into flour for human consumption (for baking pastries, pasta production, etc.). Fermented cassava can also be used for alcohol production or further processed into biogas (Kenyon and Ochieng, 2006). Most advanced processing forms can transform cassava into biodegradable packaging, starch sweeteners, etc.

METHODOLOGY

This section assessed the growth rate of cassava production and the doubling time of cassava production between 1961 and 2014 in relation to Structural Adjustment Programme (S.A.P.) and Agricultural Transformation Agenda (A.T.A.) policies during the period under study. Pre-SAP period and post-SAP periods were also assessed. The data were sourced from FAO (1961-2014) Exponential function as well as the quadratic function in trend variables were used.

The exponential function is given as:

$$Q_t = ae^{bt} \quad (1)$$

Implicit of the model was linearized to give the following equation

$$\ln Q_t = a + bt + u \quad (2)$$

where: Q_t = crop variable: production (tonnes), hectarage (ha) and yield (kg/ha), t = trend variable 1961-2014, u = error term, b = estimated coefficient, a = constant. To determine the effect of macroeconomic policies on the cassava by measuring the acceleration and deceleration in the cassava crop economy during the period under study, the log quadratic trend equation was estimated as follows:

$$\ln Q_t = a + bt + ct^2 + u \quad (3)$$

According to Ghosh, (2010), Ammani, (2015), and Nmadu *et al.*(2015), the positive significant value of 'c' indicates acceleration while a negative implies a deceleration and insignificant values imply stagnation in the growth process. The doubling time is the number of years it will take to double the rate of growth of a time series. The doubling function is presented as follows.

$$n = {}^{ln2}\!\Big/_{ln\left[1+\left(\frac{r}{100}\right)\right]} \quad (4)$$

Where n = doubling time (in years)

r = growth rate in (percent per year) obtained from the growth equation.

According to Barlett, (2011), the approximate life span of an American is 69.7, the researcher indicated that when r = 1% per year, n = 69.7.

The formula therefore can be approximated by equation (5a)

$$DT = 69/r \quad (5a)$$

(Barlett, 2011 and Nmadu, 2015) where DT = doubling time. In this study, the doubling time was determined using 55 as the approximate life span of a Nigerian. United Nations Population Fund, (UNFPA, 2019). Thus equation (5a) is transformed into:

$$DT = 55/r \quad (5b)$$

The compound growth rate was computed for each variable as follows:

$$R = (e^{b-1}) \times 100 \quad (6)$$

Where r = compound rate of growth, b = estimated coefficient from equation (1) and (3) were applied to the entire period variable and the sub-periods in the study, that is, pre-SAP, 1961-1985 SAP, SAP- 1986-1993, Post-SAP-1986-2010 and ATA- 2011-2014.

Trend of cassava hectarage, yield and output in Nigeria from 1961 to 2014

Table 1 presents the compound growth rate computed from the exponential growth equation of cassava production in Nigeria. The result shows that the mean growth rate of cassava hectarage was 8.3% which translated to negative yield of -2.4% and 7.6% growth rate of cassava output. The increase in output might be as a result of expansion of hectarage under cultivation. The entire periods under study shows an encouraging result on the hectare, yield, and output with growth rates of 4.1%, 0.1%, and 4.2% respectively. It was observed that before the introduction of the Structural Adjustment Programme (SAP), the hectares under cultivation increased by 1.8%, eventually leading to an increase in yield by 0.2% and output by 2.0%. This result is in agreement with Nmadu *et al.* (2015) that the expansion in area planted to yam and cassava was the main component of increased production. Although cassava was not a traded commodity during the Agricultural Marketing Board (pre-SAP) period, there was a positive increase in the growth rate of cassava production in Nigeria. This development was due to the establishment of the national and international collaborative cassava development programme in 1970 which made national and international research institutions become actively involved in cassava improvement and development in Nigeria and eventually led to the development of new improved varieties of cassava. It was observed that the yield of cassava during the SAP period declined and output was stagnant despite large expansion of cassava hectarage under cultivation, most likely due to outdated production technology as well as low management skills. The result under the SAP period shows the growth rate of hectarage, yield, and output to be 16%, -1.0%, and 0.0% respectively. However, there was an improvement in the growth rate of the hectarage, yield, and output after the SAP period.

Table 1 Compound Growth rate of cassava production computed using the exponential coefficients

Variable	Hectarage	Yield	Output
Entire periods	4.0713	0.1181	4.1941
Pre-SAP	1.8019	0.2222	2.0270
SAP	15.9031	-0.9645	0.0030
Post SAP	1.6068	0.0816	27.2476
ATA	18.3533	-11.6856	4.5229
Mean	8.34658	-2.44380	7.59892

Source: Computer result output, 2019

The growth rate of cassava hectarage increased by 2.0%, yield increased by 0.1%, and output increased by 27.2%. The improvement recorded in cassava production was due to presidential initiative policies introduced after SAP which led to the establishment of the Cassava Multiplication Programme (CMP) and Root and Tuber Expansion Programme (RTEP) with the objective of enhancing national food self-sufficiency, improving rural households' food security and income for poor farmers within the cassava producing States of Nigeria, (Iyagba and Anyanwu, 2012). The Agricultural Transformation Agenda (ATA) was another policy established in 2011. The result of this study under the ATA period shows a progressive growth rate of hectarage and output but with a declining rate of growth of yield. Hectarage grew by 18.4%, while yield decreased by -12.0% and output increased by 5%. The declining yield may be due to the non-adoption of modern technology and the conservative nature of the farmers. The increase in hectarage and output under ATA was probably due to farmers' accessibility to agro-inputs through a voucher system of distribution.

Table 2 shows the number of years it will take to double the rate of growth of cassava time series (Doubling time). The result shows that it will take the mean of 8 years (that is by the year 2022 from 2014) to double the rate of growth of cassava hectarage based on the current trend. This translated to high cassava output which will take 7 years to double the growth rate (that is by the year 2021) and the doubling time for yield indicated that cassava production technology is as old as 1992. This confirms the assertion that most policy reforms in the past were translated to '’hectarage expansion‟, meaning that more land is put under cultivation which leads to over-utilization of labour and low efficiency of the other inputs (Nmadu, *et al.*, 2015). The result also shows that pre-SAP and post-SAP periods will take a very long time to double the growth rate of cassava hectarage and yield.

Table 2 Doubling time for cassava production in Nigeria

variables	hectarage	yield	output
Entire period	13.5092	465.7070	13.1136
Pre-SAP	30.5233	247.5247	27.1336
SAP	3.4584	-57.0243	18,3333.333
Post-SAP	34.2295	674.0196	2.0185
ATA	2.9967	-4.7066	12.1603
Mean	8.3466	-22.5059	7.3110

Source: Computer result output, 2019

Table 3 shows that the hectarage, output, and yield exhibited significant and positive trends in the entire period for both hectarage and output except for the cassava yield. During this period the coefficient of the trend variable was significantly different from zero at 1% for hectarage and output and yield non-significant. Table 3 also presents the acceleration (A), deceleration (D), and stagnation (S) of the cassava growth rate. The results show that over the entire period, the output and hectarage accelerated with the exception of cassava yield which was decelerated. The pre-SAP period shows that hectarage was stagnant which led to a deceleration of yield and output while during the SAP period, there was an acceleration of cassava hectarage but yield declined and output remained stagnant. The post-SAP period shows an accelerated growth rate for cassava yield and output but there was a decline in the growth rate of hectarage, probably due to better farming methods and adoption of technology. The ATA period was not different from other sub-periods; the result under the ATA period indicated accelerated output with a stagnant growth rate of hectarage and yield. During all the sub-periods acceleration was observed to be highest compared to deceleration and stagnation for cassava hectarage. The implication of this is that, the policy presentation for cassava translated to a sustained increase in growth rate.

Table 3 Quadratic coefficients and nature of growth of cassava production in Nigeria

Variable	Hectarage	Yield	output
Entire periods	0.000408*** (A)	-0.00019*** (D)	0.000537*** (A)
	(0.000108)	(0.00006)	(0.000121)
Pre-SAP	-0.000011 (S)	-0.00048** (D)	-0.00058* (D)
	(0.000241)	(0.000298)	(0.000227)
SAP	0.003493*** (A)	-0.00078* (D)	0.002718 (S)
	(0.008147)	(0.003683	(0.00523)
Post SAP	-0.00175* (D)	0.001957*** (A)	0.000203*** (A)
	(0.000732)	(0.000641	(0.000842)
ATA	-0.09714 (S)	0.108884	0.011855*** (A)
	(0.043558)	(0.000206)	(0.043352)

Values in parenthesis are standard error, * 1%, ** 5%, * 10% significant levels.**
Source: Computer result output, 2019

RECOMMENDATION AND CONCLUSION

Following the introduction of policies that affect cassava production in Nigeria, the research analyzed the cassava production in Nigeria for the periods of 1961 to 2014, it was observed that it is very important to give cassava production the desired attention with an aim of improving the production in the future. The reintroduction of the Agricultural Transformation Agenda that seeks to distribute inputs through the voucher system will enable the inputs to reach the target farmers at the right time and this will encourage commercial agriculture in Nigeria. Adequate funding of research institutes and universities of Agriculture will go a long way in providing the desired high-yielding seeds to the farmers hence only technologically driven agricultural policies that will increase production and sustainability be introduced. Even though the result shows that there was more acceleration in output there was deceleration and stagnation in yield and hectarage in PRE-SAP, SAP, POST-SAP, and ATA periods. The result shows that the mean growth rate of cassava hectarage was 8.3%, negative yield of -2.4% and a 7.6% growth rate of cassava output translating into a doubling time of 8 years for cassava hectarage, -23years for yield and 7 years for output.

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ADAPTATION STRATEGIES FOR CONTROL OF DISEASES CAUSED BY CLIMATE CHANGE AMONG COCOA FARMERS IN ONDO STATE, NIGERIA

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ABSTRACT

Cocoa, a significant cash crop with a historical economic role, has been impeded by climate change, more especially the production aspect. The aspects of climate change that are actually detrimental to cocoa production by way of increase in plant diseases are a prolonged dry season and too much rainfall. Resurrecting cocoa production requires analyzing how cocoa farmers perceive and respond to climate change. This study therefore examined the adaptation strategies for the control of diseases caused by climate change among Cocoa Farmers in Ondo State, Nigeria. The study was carried out in Ondo state. Information was collected from the respondents with the aid of structured questionnaire. One hundred and forty four cocoa farmers' information was used for analysis. Data was analyzed using descriptive statistics such as frequencies and percentages. Majority (83.3%) of the cocoa farmers were male. Eighty seven percent of the farmers were married. About 79% of cocoa farmers in the study area are educated. Fifty two percent of the farmers have between 5 and 10 years of farming experience and 42% have greater than 10years of farming experience. Majority (95.8%) of the farmers have knowledge on weather. Twenty five percent of cocoa farmers in the study area are of the opinion that excessive rainfall is as a result of climate change. Six percent understand that increased incidence of drought is as a result of climate change and 16.6% affirmed that the pest and disease infestation on their farms is as a result of climate change. The strategies that were used are processing of crop to minimize postharvest losses (91.7%), crop varieties that are well acclimated (87.5%) and shade crops (87.5%). Fifteen percent reported that they experienced low effect of black pod disease on their farm after excessive rainfall, more so when fungicide is not properly or regularly sprayed, 52.1% experienced medium effect while 29.2% had high effect of the disease on their farm. Cocoa farmers in the study area have accepted the fact that climate change is a major issue in the area and they have come up with some adaptation strategies to adjust to the situation.
Keywords: *Climate change, Cocoa production, Diseases, Ondo state*

INTRODUCTION

Climate change has noticeably impacted agricultural production, particularly in the case of cocoa beans (Asante *et al*., 2017). Every stage of cocoa bean production relies heavily on favorable climatic conditions (Nabuurns *et al*., 2007). Among various climatic factors, rainfall variations exert a more substantial influence on cocoa yield than any other (Akrofi-Atitianti *et al*., 2018). The crop's sensitivity to soil water deficiency is pronounced, necessitating well-distributed rainfall throughout the growing season (Parmesan *et al*. 2022). Optimal cocoa development thrives in a hot and humid atmosphere (Adegbenro *et al*., 2023). Acidic soils are tolerable for cocoa, as long as their nutrient content remains high. The development and ripening of cocoa pods are susceptible to black pod disease, which closely correlates with weather patterns and climate (Fowler and Coutel, 2017). This disease thrives in damp environments, particularly impacting the period between July and August when the short dry spell turns wet, especially in West Africa.Oluyole and Lawal (2008) indicated that a possible loss in yields of between 50% and 70% in cocoa production as a result of climate change is imminent if no chemical measures were applied. Sucking insects like mirids pose a threat, especially when moisture deficits are severe from September to March (Okoffo *et al*., 2016). Intense light enhances insect proliferation. Notably, climate change could alter the pace and phases of cocoa pests' and pathogens' development. Hence, understanding climate change among cocoa farmers becomes paramount.

Perception, defined as an accurate grasp of reality, is key to climate change adaptation. It involves using senses to comprehend the environment. Farmers' experience is invaluable in gauging climate change. Consequently, adaptation hinges on recognizing change. Farmers who discern climate shifts are more likely to consider adaptation. Adaptation encompasses adjustments made to leverage new opportunities or mitigate losses due to external changes (Peterson *et al.*, 2011). It's a means of enhancing society's resilience to various temporal scales of change. In farming, adapting to climate change involves farm households taking action to harness positive impacts or alleviate negatives. Adaptive capacity, as per IPCC (2001), refers to a system's ability to adjust to, cope with, or exploit changes. Cocoa, a significant cash crop with a historical economic role in West Africa, has been impeded by climate change. Boosting its production requires a study on how these farmers view and adapt to climate change. This study seeks to understand climate Change and adaptation strategies for the control of diseases among cocoa farmers in Ondo State.

Objectives

The-objectives of the study-were to;

- determine the adaptation strategies for the control of diseases caused by climate change in the study area

-assess the effect of climate change on pests and diseases

METHODOLOGY

The study was carried out in Ondo state in the year 2022. Three Local Government Areas (LGAs) were purposively selected known for cocoa production. The LGAs selected were Idanre, Ondo East and Akure South. These LGAs were selected based on the fact that they are high cocoa producing LGAs in the State. Apart from this, the infestations of pests and diseases for cocoa are high in the area. Fifty farmers were randomly selected in each LGA. A total of one hundred and fifty cocoa farmers were selected in the state in year 2022, after sorting out for missing data one hundred and forty four cocoa farmers' information were used for analysis. Information was collected from the respondents with the aid of structured questionnaire. The data retrieved from the information collected were analyzed using descriptive statistics such as frequencies and percentages. The statistical package used for the analysis is STATA.

RESULTS AND DISCUSSION

Socio economic characteristics of Cocoa Farmers in Ondo state

Table 1 revealed the Socio economic characteristics of cocoa farmers in Ondo state. Majority (83.3%) of the cocoa farmers were male. Oluyole *et al*. (2023) affirmed that men are mostly involved in tree crop production while women are more involved in processing. Eighty seven percent of the farmers were married, 6.3% were single, 4.2% were divorced while 2.1% were widowed. The marital status of farmers can play a great role in labour availability on the farm. For farmers that are married they might use more of family labour as compared to hired labour (Pierotti *et al*., 2022). Their wives and children can assist in harvesting, breaking pods, fermentation and drying of cocoa beans. About 79% of cocoa farmers in the study area are educated. They either have a primary, secondary or tertiary level of education. Education plays a great role in the adoption of new techniques. Fifty two percent of the farmers have between 5 and 10 years of farming experience and 42% have greater than 10years of farming experience. Wongnaa and Babu (2020) affirmed that farmers' years of experience in cocoa farming could assist them in adapting to climate change by using local methods in cocoa farming.

Table 1: Socio economic characteristics of Cocoa Farmers in Ondo state

Variable	Freq(144)	%
Location		
Sex		
Male	120	83.3
Female	24	16.7
Marital status		
Single	9	6.3
Married	126	87.4
Divorced	6	4.2
Widowed	3	2.1
Educational level		
No formal education	30	20.8
Primary	42	29.2
Secondary	63	43.8
Tertiary	9	6.2
Farming experience(years)		
1-4	9	6.3
5-10	75	52.0
>10	60	41.7

Source: Field Survey, 2022

Table 2 presented the Concept of Climate change and cocoa cultivation among farmers in the study area. Majority (95.8%) of the farmers are aware of weather changes. This would enable them to know ways to mitigate and adapt to climate change. Twenty five percent of cocoa farmers in the study area are of the opinion that excessive rainfall might as a result of climate change. Six percent understand that increased incidence of drought is as a result of climate change. Nineteen percent understands that the crop failure they encounter on their farm is as a result of climate change, 10.4% of the farmers ascribe the decline in cocoa yield to climate change, 16.6% affirmed that the pest and disease infestation on their farms is as a result of climate change while 22.9% ascertained that high wind and heat waves they experience is as a result of climate change. Sixty three percent of cocoa farmers got information on climate change from radio/television while the others got information from friends, extension workers and farmers' cooperatives. Nine out of ten farmers in the study area have knowledge on the effect of climate change either positive/negative. Thirty one percent of the farmers reported that their cocoa yield was low compared to the previous years. Twenty seven percent reported that their yield was moderate, 16.7% reported that it was high while 25% reported that it was normal. Their responses above affirmed that most of the cocoa farmers experienced climate change. Eighty eight percent of cocoa farmers in the study reported that they have been experiencing climate change for between 1 and 10years.

Table 2: Concept of Climate change and cocoa cultivation

Variable	Freq. (144)	%
Awareness of weather changes		
Yes	138	95.8
No	6	4.2
Understanding on climate change		
Excessive rainfall	36	25.0
Increased incidence of drought	9	6.3
Crop failure	27	18.8
Decline in yield	15	10.4
Pest and Disease infestation	24	16.6
High wind and heat waves	33	22.9
Source of Information on climate change		
Radio/Television	90	62.5
Friends	6	4.2
Extension workers	33	22.9
Farmers' cooperatives	15	10.4
Knowledge on the effect of climate change on farming practices		
Yes	136	95.8
No	6	4.2
Effect of climate change positive/negative	78	54.2
Yes	66	45.8
No		
Yield compared to the previous years		
High	24	16.7
Moderate	39	27.0
Low	45	31.3
Normal	36	25.0
How long have you been noticing climate change (years)		
1-10	126	87.5
>10	18	12.5

Source: Field Survey, 2022

Adaptation Strategies to Climate Change

Table 3 revealed the strategies that cocoa farmers in the study area used to adapt to climate change. Some of the strategies that were used are processing of crop to minimize postharvest losses (91.7%), crop varieties that are well acclimated (87.5%), shade crops (87.5%), recommended planting distance (87.5%), planting of early maturing cocoa variety (83.3%), organic matter (81.3%), use of chemicals such as fungicide, insecticide and herbicide (81.3%), reclamation of wet land/river valley (81.3%). The other strategies used by the farmers are conservation of soil and water, making of contour bund around farm land, planting under existing trees, increase in number of weeding of crop land and protection of water shed and mulching. Kosoe and Ahmed (2022) also confirmed the use of strategies mentioned above in Ghana.

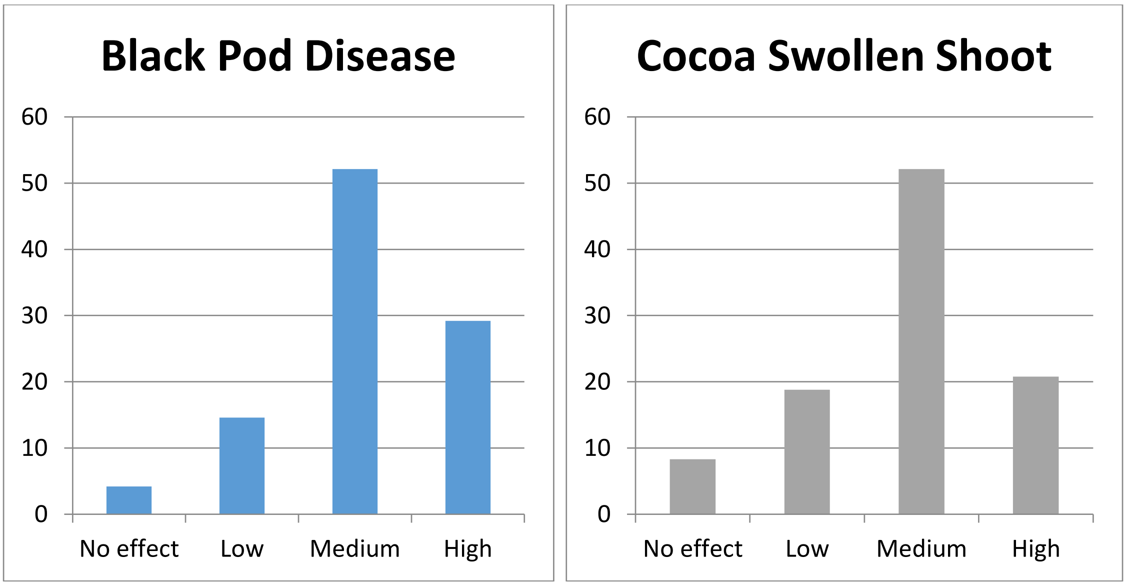
Table 3: Adaptation Strategies to Climate Change

Variable	Frequency	%
Conservation of soil and water	114	79.2
Use of organic matter	117	81.3
Use of inorganic fertilizer	99	68.8
Planting pest and disease resistant crop	90	62.5
Use of crop varieties that are well acclimated	126	87.5
Draining of wetland for crop cultivation	93	64.6
Making of contour bund around farm land	114	79.2
Use of shade crop	126	87.5
Planting under existing trees	108	75.0
Use of irrigation system/water storage	93	64.6
Reforestation/Afforestation	90	62.5
Use of chemicals e.g. fungicide, insecticide, herbicide	117	81.3
Increase in number of weeding of crop land	108	75.0
Planting of early maturing cocoa variety	120	83.3
Protection of water shed and mulching	114	79.2
Planting of crop with early rainfall	111	77.1
Mixed farming practices	108	75.0
Change of planting date	87	60.4
Use of recommended planting distance	126	87.5
Changing the timing of land preparation	87	60.4
Changing harvesting date	75	52.1
Migrating out of climate risk areas	78	54.2
Processing of crop to minimize post harvest losses	132	91.7
Reclamation of wet land/ river valley	117	81.3

Source: Field Survey, 2022

Effect of Climate Change on Pests and Diseases

In table 4 cocoa farmers reported the effect of climate change on pests and diseases. Fifteen percent reported that they experienced low effect (that is, little effect) of black pod disease on their farm, 52.1% experienced medium effect while 29.2% had high effect of the disease on their farm. In general, 95.9% of the farmers (Figure 1) affirmed that they experience black pod disease on their farms showing that black pod disease is a major issue among cocoa farmers in the study area. Also in figure 2, 8% of cocoa farmers in the study area do not experience cocoa swollen shoot on their farm while 18.8% had low effect, 52.1% had medium effect and 20.8% had high effect. Furthermore 12.5% of the farmers did not experience vascular wilt disease on their farm while 16.7% had low effect, 50.0% moderate effect and 20.8% had high effect. Other diseases that cocoa farmers in the study area highly experienced are leaf defoliation (41.7%), cherelle wilt (41.7%). Okeniyi *et al*. (2021) affirmed that as a result of climate change there is the occurrence of pests and diseases on cocoa such as cherrele wilt, mirid, termite infestation and cocoa swollen shoot.



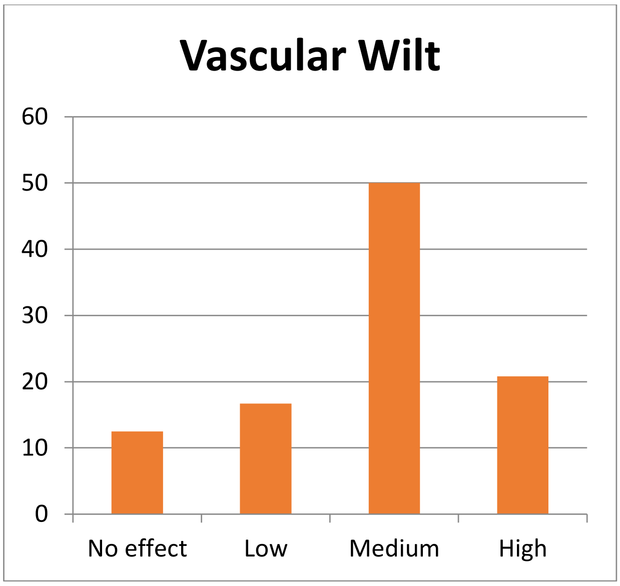


Figure 1: Effect of Climate Change on Black Pod Disease
Figure 2: Effect of Climate Change on Cocoa Swollen Shoot
Figure 3: Effect of Climate Change on Vascular Wilt Disease

Table 4: Effect of Climate Change on Pests and Diseases

Variable	Frequency	%
Die back of shoot		
No effect	18	12.5
Low	24	16.7
Medium	66	45.8
High	36	25.0
Stem borer		
No effect	18	12.5
Low	33	22.9
Medium	60	41.7
High	33	22.9
Pod borer		
No effect	18	12.5
Low	51	35.4
Medium	51	35.4
High	24	16.7
Mirid		
No effect	3	2.1
Low	39	27.1
Medium	63	43.7
High	39	27.1
Cherelle wilt		
Low	51	35.4
Medium	33	22.9
High	60	41.7
Nematode Infection		
No effect	15	10.4
Low	54	37.5
Medium	42	29.2
High	33	22.9
Stem Canker		
No effect	15	10.4
Low	57	39.6
Medium	39	27.1
High	33	22.9

Leaf defoliation		
No effect	3	2.1
Low	48	33.3
Medium	33	22.9
High	60	41.7
Yellowing and shedding of leaves		
No effect	15	10.4
Low	24	16.7
Medium	51	35.4
High	54	37.5
Rating of the effect of climate change on pesticide usage		
No Idea	9	6.2
No effect	3	2.1
Low	42	29.2
Moderate	81	56.3
High	9	6.2

Source: Field Survey, 2022

CONCLUSION AND RECOMMENDATION

Cocoa farmers in the study area affirmed that climate change is a major issue ~~and~~ have come up with strategies to adapt to the climate change. Specifically, some of the adaptation strategies that are majorly implemented by the farmers are conservation of soil and water, use of organic matter, use of shade crop, use of chemicals such as fungicide, insecticide, herbicide, use of recommended planting distance and timely processing of crop to minimize postharvest losses. It is hereby recommended that scientists at the Cocoa Research Institute of Nigeria should come up with new varieties of cocoa that are resistant to pests and diseases brought about as a result of climate change incidence.

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A SYSTEMATIC REVIEW OF THE IMPACT OF CLIMATE SMART AND NUTRITION SENSITIVE AGRICULTURE ON NATIONAL FOOD SECURITY IN NIGERIA

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ABSTRACT

Climate change and its impact on agriculture are major concerns for a food secured economy especially for developing countries like Nigeria. The carbon footprint of agriculture is also a concern for future climate. Nutrition Sensitive Agriculture seek to ensure the production of a variety of affordable, nutritious, culturally acceptable and safe food to meet the dietary requirement of populations in a sustainable manner. Food security is a situation by which all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Agriculture provides the foods that can improve nutrition, and nutrition supports agricultural labour requirement by providing the energy and good health farmers need to maximize productivity. These make sustainable agricultural practices a prerequisite for National Food Security today. This study reviewed the impact of climate smart and nutritional sensitive agriculture on national food security in Nigeria. The objectives of the study are to: identify climate smart and nutrition-sensitive agricultural practices used by small and medium scale farmers; identify the factors influencing the adoption of climate smart and nutrition-sensitive agriculture by small and medium scale farmers and to ascertain the impact of climate smart and nutrition-sensitive agriculture on National Food Security in Nigeria. The study adopted systematic review of literature in which accessible research results of adequate quality were identified, critically reviewed and integrated with the aim of generating fresh synthetic ideas. Secondary data were used in this study. Relevant scientific published documents were retrieved using the Web of Science (WoS) and Scopus core collection databases. The literature search was conducted on various databases, including Google Scholar, Scopus (Elsevier) and Springer (Nature) and, FAOSTAT using the Search Technique. Articles considered for inclusion contained essential vital words from the topic. A random google search recognizing the appropriate keywords was used and results gotten from the search were used for the systematic review of twenty-five (25) articles. The result showed that, crop and livestock diversification, planting of cover crops to increase soil fertility, use of drought resistant varieties and use of organic manure were the major climate smart and nutrition sensitive agricultural practices used by small scale farmers in Nigeria. The adoption of various climate smart and nutrition-sensitive agricultural strategies was significantly influenced by socioeconomic, institutional and climate related factors. The study concluded that the adoption of climate smart and nutrition-sensitive agriculture is low among the farmers. Also, impact of climate smart and nutrition-sensitive agriculture include enhancing achievement of national food security, enhancing soil quality, increases food productivity, reduces greenhouse gas emission and restoring degraded lands. Nonetheless, policy factors such as extension service delivery can be triggered to enhance the adoption of Climate Smart and Nutrition Sensitive Agriculture among the small and medium scale farmers and ensure National Food Security in Nigeria.
Keywords: *Climate change, Climate Smart Agriculture, Nutrition Sensitive Agriculture*

INTRODUCTION

Climate Smart Agriculture (CSA) has been presented as an alternative form of agriculture for conserving the environment while addressing the food needs of the world's population (FAO, 2014). The concept was originally put forth in 2010 by FAO after the Hague Conference on Agriculture, Food Security and Climate Change in 2009

(FAO, 2010; World Bank, 2010). According to FAO (2010), the main aim of CSA is to repackage agriculture in the context of a changing climate, to assure a 'triple win', thus, adaptation, mitigation and development. Climate Smart Agriculture is thus defined as a form of agriculture that sustainably increases agricultural productivity and incomes; enhances adaptation and building resilience to climate change, reducing or removing Greenhouse Gases (GHGs) where possible, and enhancing the achievement of national food security and the sustainable development goals (FAO, 2014). In a related view, Shea (2014) suggests that CSA is a focus-based concept that involves developing new technologies that can help farmers transition from current strategies to more climate-aware practices and encourage farmers to abandon or lessen reliance on methods that increase GHGs. It adopts some form of sustainable land management practices that engage farmers in sustainable intensification measures such as agroforestry, conservation tillage, residue management, green manuring and improved water management to improve agricultural performance (Palombi and Sessa, 2013; DeLonge *et al*., 2016). It also enables farmers to use their knowledge and skills more effectively, share information, opt for more efficient pro-environmental technologies and build stronger associations to facilitate effective negotiation of better market prices (Branca *et al*., 2011).

Agriculture is fundamental to food production. Traditional agricultural development tends to focus on productivity, production and income rather than nutrition. Agriculture, including CSA, must transform to become nutrition-sensitive in order to deliver on healthy diet to ensure national food security (FAO, 2017). Nutrition-Sensitive Agriculture (NSA) is an approach that addresses potential disconnect between agriculture and nutrition. It seeks to ensure the production of a variety of affordable, nutritious, culturally acceptable and safe food to meet the dietary requirement of populations in a sustainable manner (GIZ, 2016). It has a goal of improving human nutrition (UNICEF, 2010). It is a solution that recognizes the interconnections with agriculture and nutrition. Unlike conventional agriculture interventions whose focus is on increased agricultural production and income, the primary objective of NSA interventions is to use food-based approaches to improve nutrition (GIZ, 2016).

Although, the government and other stakeholders have promoted a number of Climate Smart and Nutrition-Sensitive Agricultural practices, some small and medium scale farmers have adopted these practices on their farms voluntarily. However, there is a dearth of knowledge on the drivers of the choice and use of the Climate Smart and Nutrition-Sensitive Agricultural practices and their implication on household food security. Therefore the objectives of this study are to identify Climate Smart and Nutrition Sensitive Agricultural practices used by small and medium scale farmers in Nigeria, identify the factors influencing the adoption of Climate Smart and Nutritional Sensitive Agriculture by small and medium scale farmers in Nigeria, and ascertain the impacts of Climate Smart and Nutritional Sensitive Agriculture on National Food Security in Nigeria.

RESEARCH METHODOLOGY

Study Area

The study was conducted in Nigeria, which comprises of 36 States and the Federal Capital Territory (FCT) under the Six (6) Geo-Political Zones. Nigeria is located in West Africa along the western coast of Africa.

Research Design

The study adopted systematic review of literatures in which accessible research results of adequate quality were identified, critically reviewed and integrated to generate fresh synthetic ideas.

Types and Sources of Data

Secondary data were used in this study. Relevant scientific published documents were retrieved using the Web of Science (WoS) and Scopus core collection databases. These databases are widely used in most review studies. They provide a wide range of peer-reviewed research documents, including scientific articles, books/book chapters, and conference proceedings, among others, in almost all scientific disciplines.

Method of Data Collection

The literature search was conducted on various databases, including Google Scholar, Scopus (Elsevier) and Springer (Nature) and, FAOSTAT using the Search Technique. Articles considered for inclusion contained key words from the topic. A random google search recognizing the appropriate keywords was used and results gotten from the search were used for the systematic review of twenty-five (25) articles.

Method of Data Analysis

Data were analyzed using descriptive statistics.

RESULTS AND DISCUSSION

Climate Smart and Nutrition Sensitive Agricultural Practices used by Small Scale Farmers

The type of Climate Smart and Nutrition Sensitive Agricultural practice used by small scale farmers in Nigeria is presented in Figure 1.

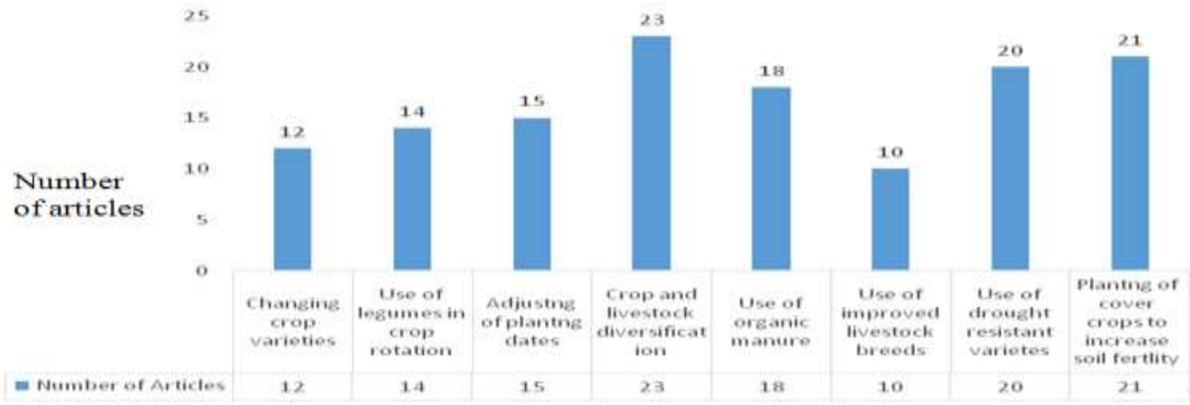

Figure 1. Climate smart and nutrition sensitive agricultural practices

Crop and livestock diversification, planting of cover crops to increase soil fertility, use of drought resistant varieties and use of organic manure were the major climate smart and nutrition sensitive agricultural practices used by small scale farmers in Nigeria. The reason for high adoption of planting of cover crops to increase soil fertility and drought tolerant varieties was traced to the need to provide adaptive measures against short rainfall duration in the Nigeria. Nevertheless, the cover crops which are mostly legumes also provide some essential dietary needs to the household and ensure national food security. The high adoption of agronomic practices in general was based on the realization of its yield enhancing potential which has made dissemination of the practice widespread. As fertilization is expected to enhance the capacity of improved seed varieties to express yield potential optimally, farmers are expected to use fertilizers. To be climate smart, the blend of both organic manure and inorganic fertilizers is recommended (FAO, 2013).

Factors influencing the Adoption of Climate Smart and Nutrition-Sensitive Agriculture by Small and Medium Scale Farmers
Socio-economic factors

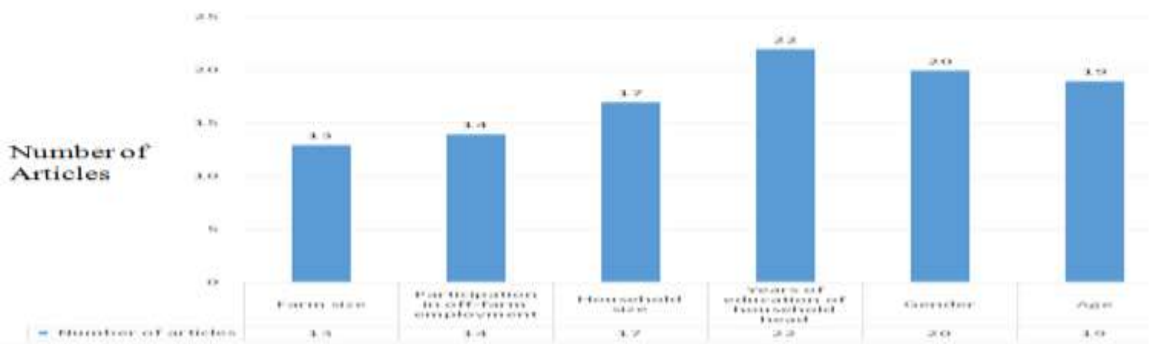

Figure 2. Socio-economic factors influencing the adoption of climate smart and nutrition-sensitive agriculture by small and medium scale farmers
The socio-economic factors influencing the adoption of Climate Smart and Nutrition-Sensitive Agriculture by smallholder farmers is presented in Figure 2. The factors include age, sex, years of education of household head, household size, farm size and participation in off-farm employment. The result shows that a number of these factors had substantial influence on the adoption of climate smart and nutrition-sensitive agricultural practices. The sex of the household head had a positive effect on the adoption of climate smart and nutrition-sensitive agricultural practices. Male heads were noted to have a higher probability of adopting climate smart and nutrition-sensitive agricultural practices vis-à-vis their female counterparts. The estimated positive effect of sex on climate smart and nutrition sensitive agricultural practices is consistent with the findings of Abu *et al.* (2018). Contrary to this finding, Adedeji *et al.* (2017) estimated that female farmers have a higher probability of adopting row planting of rice. The number of households is used as a proxy for labour availability for farm activities. The result

shows that higher household size substantially affects the adopting climate smart and nutrition-sensitive agricultural practices. This finding is supported by studies such as Idrisa *et al.* (2014) and Adedotun *et al.* (2020). Education plays a crucial role in improving the human capital and the understanding of climate smart and nutrition-sensitive agriculture and the need for adoption. The result shows that education highly influenced the adoption of the practices. This implies that higher education leads to the adoption of more climate smart and nutrition-sensitive agricultural technologies. This is consistent with the findings of Ayorinde *et al.* (2022) which that education enhances the adoption of climate smart and nutrition-sensitive agricultural practices.
Climate related shocks

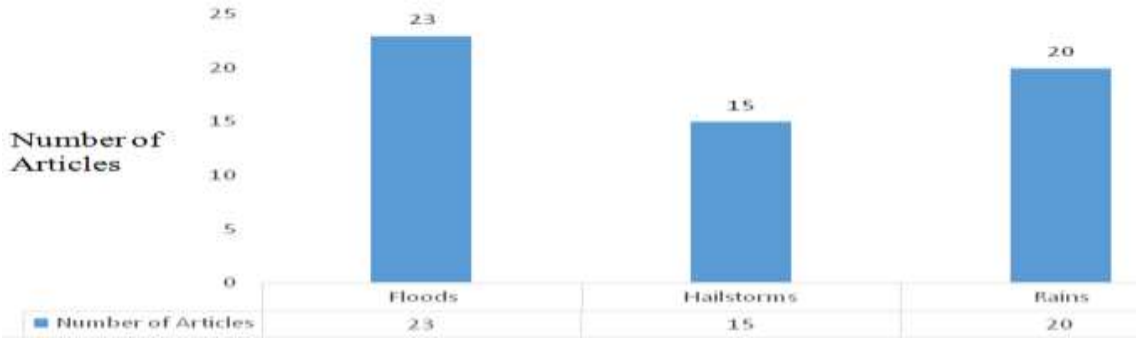

Figure 3. Climate related factors influencing the adoption of climate smart and nutrition-sensitive agriculture by small and medium scale farmers
The climate related factors include floods, hailstorms and rains. These factors affect the adoption of Climate Smart and Nutrition-Sensitive Agricultural practices (Figure 3). These farmers could be implementing a responsive strategy that included farm risk reduction through diversified production means. Previous study by Funminiyi *et al.* (2020) had a contrary result where frequent hailstorms were the main sources of production risks related to climate change that discouraged farmers adoption of production techniques for yield stability.
Institutional characteristics

Figure 4. Institutional factors influencing the adoption of climate smart and nutrition-sensitive agriculture by small and medium scale farmers
Institutional factors affecting adoption of climate smart and nutrition-sensitive agriculture were highlighted from the articles. This includes distance to the market, group membership, extension agents and credit access (Figure 4). Access to extension services greatly informed the adoption of climate smart and nutrition sensitive-agriculture by the farmers. Thus, farmers who had access to extension services had higher probability of adopting the technologies than those who did not. Extension officers are generally responsible for transferring technologies to the farmers. Therefore, it is expected that the farmers become more aware of these technologies and their importance. This justified the need for enhancing the provision of extension service to farmers, especially, in the era of climate change and the rapid technological advancement. Adebayo and Ojogu (2019) also estimated a positive effect of extension access on technologies adoption.

Impact of Climate Smart and Nutrition Sensitive Agriculture on National Food Security

The impact of climate smart and nutritional sensitive-agriculture on national food security in Nigeria is presented in Figure 5.

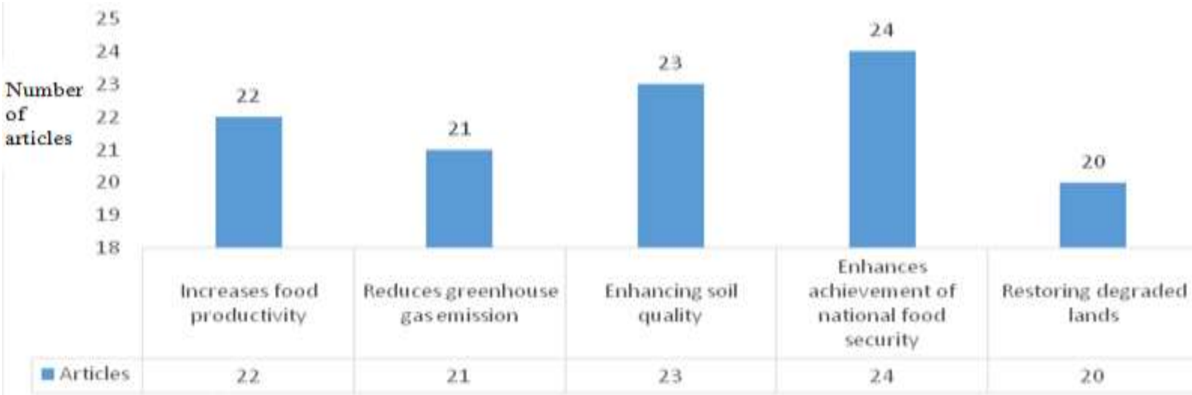

Figure 5. Impact of climate smart and nutrition-sensitive agriculture

From the results in Figure 5, impact of climate smart and nutrition-sensitive agriculture has great effect in enhancing achievement of national food security, enhancing soil quality, increases food productivity, reduces greenhouse gas emission and restoring degraded lands. This is in line with Igberi *et al.* (2022) findings which showed that adoption of climate smart and nutrition-sensitive agriculture sustainably increases productivity and resilience (adaptation), reduces/removes GHGs (mitigation), and enhances the achievement of national food security and the sustainable development goals. Similarly, Halliru *et al.* (2021) reported that practicing of climate smart and nutrition-sensitive agriculture are relevant as they enhance soil quality, brings about adaptation and mitigation benefits by regulating carbon, oxygen, and plant nutrient cycles, leading to enhanced resilience to drought and flooding, and to carbon sequestration. In terms of child stunting, wasting, low birth-weight, Nigeria is at or slightly below the Sub-Saharan Africa's average, and from the global perspective; far from ideal. Anemia in women of reproductive age, though the data is outdated, is considerably higher than the average of the Central and Western Africa and also ranked very close to the bottom in the world. While the situation requires continuous attention, what is noteworthy about Nigeria's nutrition situation is that the country is seemingly making good progress in tackling under-nutrition in the past few years. To realize the country's desire to achieve these global targets, there appear to be two important dimensions that need attention: improving major underlying drivers of nutrition through multi-sectoral approaches; and adoption of climate smart and nutrition-sensitive agriculture.

CONCLUSION AND RECOMMENDATIONS

Agronomic practices in term of cultivation of high yielding, drought tolerant, disease and pest resistant varieties were the most adopted climate smart and nutrition-sensitive agricultural practices. It can be concluded from the review that, climate smart and nutrition-sensitive agriculture has a positive impact on food security. It further allows for more efficient resource use of agricultural production systems which offered considerable potential for increasing agricultural productivity, income, food security and the resilience of rural livelihoods while reducing the intensity of agricultural emissions. It is therefore recommended that government policy and supportive programmes towards climate change mitigation and adaptation should focus on adoption of climate smart and nutrition-sensitive agricultural practices especially those ones that were not highly adopted by the small and medium scale farmers. Also, efforts should be made by Universities and Research Institutes and to adequately train the Agricultural Extension Agents on all the components of climate smart and nutrition-sensitive agricultural practices.

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ASSESSMENT OF AGRICULTURAL EXTENSION TRAINING PROGRAMMES AMONG SMALLHOLDER FARMERS IN NINGI LOCAL GOVERNMENT AREA OF BAUCHI STATE, NIGERIA

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ABSTRACT
The study assessed Agricultural extension training programmes among smallholder farmers in Ningi local government area of Bauchi State, Nigeria. A multi-stage sampling method that includes purposive and random sampling was used to select 120 respondents for the study. Data were collected with aid of questionnaires and analyzed using descriptive statistics (mean, standard deviation, frequency and percentage) and inferential statistics (logistic regression analysis). The result reveal that, majority of the respondents (71.7%) were male with 35.8% of the respondent having mean age of 44.1. Almost half of the farmers (49.2%) having mean farm size of 3.7 land. The mean score of farmers' perception regarding extension agent performance shows that, the extension agents provide good ideas that help in improving farmers' production with the highest mean score of 2.2 and that the extension agent provide continuous support to help the application and implementation of the information taught, having the lowest mean score of 1.7.The result of the logistic regression analysis shows that the training need of farmers were significantly (P<0.05) influenced by marital status (2.350), farming experience (3.444), and number attending the extension training (2.020).The study recommends that emphasis should be place on the creation of small farmer groups in which training can be easily conducted.
Key words: *Assessment, Agricultural, Extension, Training, programmers*

INTRODUCTION
Almost all countries in the world deliver some type of extension services to help rural people advance their agricultural productivity and improve their living standard (Ijeoma and Adesope, 2015). Extension is responsible for serving about one billion small-scale farmers in the world (Davis, Nkonya, kato and Nkuba, 2010). The improvement of agricultural sciences and technology has brought about dramatic changes in the agricultural sector (Nagel, 1997). This has led to the increased need and opportunity for investigating the effectiveness of agricultural extension services in various parts of the world. Also, this situation stimulates the need for new approaches to promote the transition of new innovations into concrete benefits to poor farmers in developing countries (Hellin, 2012).
Over the years, agricultural extension has been at the fore-front in the delivery of adequate information to farmers for increased productivity. According to Apantaku and Oyegunle (2016) and Agbamu (2007), agricultural extension service delivery all over the world has been concerned with communicating research findings and improved agricultural practices to farmers. The roles of extension today go beyond technology transfer and training of farmers but include assisting farmer to form groups, dealing with marketing issues, addressing public interest issues in rural areas such as resource conservation, health, monitoring of food security and agricultural production, food safety, nutrition, family education, and youth development and partnering with a broad range of service providers and other agencies (Ijeoma and Adesope, 2015).
Agricultural extension aims to disseminate relevant information for effectiveness and efficiency of agricultural activities but is confronted with certain constraints. Iwena (2008) identified absence of credit facilities, insufficient motivation of the personnel, inadequate resources, poor transportation network, high level of farmers' illiteracy and language barriers as some of the constraints faced by farmers in Nigeria. According to Munyua (2000), lack of access to basic agricultural knowledge and information by rural farmers can be assumed to be as a result of some constraints to effectiveness of agricultural extension activities which have made these farmers to stick to

their old traditional methods of farming system and animal husbandry practice, hence resulting in poor crop and livestock productivity.

The current poor performance of the agricultural extension system is as a result of inadequate resources to enable it to perform its role effectively. But perhaps a more important factor is its bureaucratic organization, which tends to contradict its very mission of working closely with farmers and with other service agencies to stimulate agricultural modernization. Mattee (1994), and Boone, Gartin, Wright, Lawrence, and Odell (2002) insisted on the importance of improved agricultural extension in the 21st century given that the agricultural sector is facing many technological advances, new agricultural laws, and innovative marketing strategies, all of which need to be communicated to farmers through well-established extension programs. This calls for the need to study all aspects related to extension, including the main stakeholders (farmers), in looking for better means of improving the extension programs.

Thus, the study to identified farmers' perceptions in order to find better means of helping them effectively to participate in the extension training programmes by developing programs and use of methods that meet their needs.

The broad objective of the study was to assess the agricultural extension training programs among smallholder farmers in Ningi Local Government Area of Bauchi State, Nigeria. However, the specific objectives were to: identify the socio-economic characteristic; examine the perceived attitude of farmers toward agricultural extension training programs; determine the influence of socio-economic characteristic of farmers on training needs of agricultural extension program in respondents in the study area.

METHODOLOGY

The study area was Ningi Local Government Area is among the 20 Local Government Areas in Bauchi state. It is divided in to eleven (11) wards and has a total land area of 4,625km square and located on 11° 4, 9° 34 E /11°.67 N 9.5°-67 E and has a total population of 387,192 (NPC 2006). The headquarters of the Local Government Area (Ningi) is 102 km away from the state capital (Bauchi) along Bauchi-Kano federal highway.

The population for this study consisted of farmers growing cash and food crops in Ningi local government area of Bauchi state. A multi-stage sampling technique was employed for the study. In the first stage, purposive sampling was used to select five (5) wards (Balma, Kudu- yamma, Tiffi-guda, Nasaru and Dingis ward), this is because of the presence of extension activities in the areas. In the second stage, two (2) villages were randomly selected from each ward resulting in a total of ten (10) villages. In the third stage, 120 farmers were randomly selected from the sample frame of 2415 farmers' base on the data collected from Agric department Ningi LGA (2018). This forms the sample size of the study and it represent 5% of the sample frame. Both Primary and secondary information were used for the study, structured questionnaire was used to obtain primary information. While secondary information was obtained through literature review and record from Agric Department Ningi LGA. The questionnaires used were both closed and open ended.

Data analysis was conducted using the Statistical Package for the Social Sciences (SPSS) computer program. Descriptive and inferential statistics consisting of mean, standard deviation, frequency table, percentages, and regression analysis were used to analyze the data. The analysis also involved the identification of the characteristics of the respondents and how they relate to various aspects of the study. Frequencies and percentages were used to describe farmers' socio-economic characteristics.

In order to determine the influence of selected socio-economic characteristic on farmers training needs, the Binary Logistic Regression model that was used and is specified below:

$$\text{LOG } \frac{P}{1-P} = \text{LOG } Y = \alpha + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \beta 5X5 + \beta 6X6 + \beta 7X7 + \beta 8X8 + \mu$$

Where;

LOG $\frac{P}{1-P}$ = Log of the probability (P) of needed training relative to no need training

Needed training = 1; No need training = 0

X1 = Age (in years)

X2 = Sex (male =1; female = 0)

X3= Marital status (married=1; otherwise=0)

X4 = Level of education (in years)

X5 = Household size (in number of persons)

X6 = Farm size (in number of hectares)

X7 = Farming experience (in years)

X8 = Number of attending the extension training in a mouth (once=1; otherwise=0)

μ = error term

RESULT AND DISCUSSION

Distribution of Respondents by Sex: The study revealed that most of the respondents (71.7%) were male only 28.3% were female. This finding is consistent with the study by Okwusi and Aboh (2007) in which 95% of the sample of 20 respondents interviewed were male. This disparity was also reflected in the number of women taking part in extension training as well, as in this study.

Distribution of Respondents by Age: As indicated in Table 1, the distribution of respondents based on ages, revealed that the mean age is 44 years. This showed that most of the farmers were middle age farmers. The findings regarding the distribution of respondents based on age in this study is consistent with the study by Modibo *et al*., (2010).

Farm Size Distribution of Respondents (Ha): According to the result obtained almost half of the farmers (49.2%) owned about two to four hectares on which different crops were grown. Only 0.8% of the respondents owned more than 10 hectares, but indicated that they did not cultivate all of it. Instead, they leased some of it to other farmers in need. In addition, 24.2% of the respondents had farms with less than 2 hectares, 18.3% owned 5-7 hectares and 7.5% of the respondent owned 8-10 hectares. Most of the farms were not located at one site. The result also revealed that the mean farm size is 3.7 hectares this implies that a greater proportion of the respondent were small-scale farmers.

This result is in line with the study by Olatunji (2005). Ijeoma and Adesope (2015), as pointed out by Ibitoye and Onimisi (2013), total farm output is higher if bigger farms have higher productivity as compared to small ones. This may justify the reason for food insecurity in most rural families despite the fact that they are busy with farming activities each and every season.

Table 1: Socioeconomic characteristics of respondents

Variable		Frequency	Percentage	Mean
Age				
Male		86	71.7	
Female		34	28.3	
		120	**100**	
Age				
	15-25	7	5.8	
	26-35	23	19.2	
	36-45	35	29.2	
	46-55	43	35.8	
	56-65	9	7.5	
	66-75	3	2.5	
		120	**100**	**44.1**
Farm size				
	Less than 2 ha	29	24.2	
	2-4	59	49.2	
	5-7	22	18.3	
	8-10	9	7.5	
	More than 10 ha	1	0.8	
		120	**100**	**3.7**

Distribution of Respondents According to Farmers' Perceptions Regarding Extension Agents' Performance

The mean score of farmers' perceptions and views about the performance of the extension agent in providing useful ideas to help farmers improve production was 2.17, (Table 2), whereas the mean score of their perception of the availability of the extension agent in helping farmers when they are in need was 2.1. Furthermore, the mean scores of the farmers perceptions of the extension agents' preparedness for the training programs was 1.2; extension agents having all training facilities was rated 1.8; extension agents being friendly and easily approachable was rated 2.1; the efficiency of the extension agents in helping farmers was rated 1.8 and extension agents providing continuous support to help farmers implement technologies was rated 1.7 (Table 3).

Table 2: Respondents' Perceptions of Extension Agents' Efficiency in Training and Helping Farmers

Perception	N	Min	Max	M	SD
Extension agent provide good ideas that help in improving my production	120	1	5	2.1750	1.25591
Availability of extension agents to help farmers	120	1	5	2.1333	1.24979
Extension agents are well prepared during training session	120	2	5	1.1750	1.01801
Extension agent has all training Facilities	120	2	5	1.8083	0.99828
The extension agent has the efficiency in helping farmers	120	1	4	1.7833	1.05467
Extension agents are friendly and easily approachable for advice	120	1	5	2.0500	1.31993
Extension agent provides continuous support to help the application and implementation of the information taught	120	2	5	1.666	0.99015

Source: Field survey, 2018

Note. Perception statements were rated on a Likert- scale on which 1 = strongly agree, 2 = agree, 3 = I don't know, 4 = disagree, and 5 = strongly disagree.

Binary Logistic Regression

Table 3: Influence of Socio-economic characteristics of Farmers on their Training Needs

Variable	B	S.E	Wald	Sig.	Exp(B)
Age	0.054	0.057	0.922	0.337	1.056
Sex	0.587	0.614	0.915	0.339	1.799
Marital status	-1.442	0.940	2.350*	0.125	0.236
Educational level	-0.063	0.081	0.607	0.436	0.939
House hold size	-0.073	0.069	1.131	0.288	0.930
Farm size	0.050	0.097	0.259	0.611	1.051
Farming experience	0.147	0.079	3.444*	0.063	1.159
Number of attending The Extension training	-.0631	0.444	2.020*	1.55	0.532
Constant	-3.646	1.725	4.468*	0.35	0.26
-2 Log likelihood				127.382	
Cox & Snell R square				0.160	
Nagel kerke R Square				0.225	

Source: Field survey, 2018

The result of the binary logistic regression in Table 4.17 shows that the training need of farmers were significantly ($p<0.05$) influenced by marital status, farming experience, and number of attendances to extension training.

CONCLUSIONS AND RECOMMENDATIONS

It was concluded that most farmers understand the usefulness of extension training programs in improving their agricultural production, there is a great need to improve the way services are offered as well as the dissemination of information about training to capture the attention of many farmers regarding the training to be conducted.
The study recommends that the extension program planners should focus on current problems facing farmers and provide technology and knowledge that are of interest to farmers. This can best be done by employing a participatory approach to extension as well as by strengthening collaboration between extension and research so as to be able to update farmers on any new innovations.

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FLOWERING AND SEED SETTING POTENTIALS OF SWEET POTATO AS PROPAGATED BY SEED AND VINE IN LAFIA, NASARAWA STATE, NIGERIA.

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23rd – 27th Oct., 2023

ABSTRACT
An experiment was conducted during the rainy season of 2021in botanical garden of federal university of Lafia, Nasarawa state to evaluate the flowering seed setting potential of sweet potato (Ipomea batatas (L) Lam). Vine and seed of five different accessions ,namely;TIS8164,TIS87/0087,UMUSPO3,UMUSPO4,EX-IGBARIAN were used and these were laid out in a Randomized complete block design (RCBD)with three(3)replications. Flowering parameters such as mean number of days to onset of flowering and mean number of flower produced per plant were observed in the field while pollen viability test was conducted in the laboratory. The analysis of variance (ANOVA) result for mean number of days to onset of flowering showed that significant difference existed between the different sweet potato accessions at 5% level of probability across both seed and vine. Highest mean number of days to onset of flowering for seed accessions was recorded in EX-IGBARIAN with 58.00 days, and least mean number of days to onset of flowering for seed accessions was recorded in TIS8164 with 54.33days.While the highest mean number of days to onset of flowering for vine accessions was recorded in EX-IGBARIAN with 63.33days and the least mean number of days to onset of flowering for vine accessions was recorded in UMUSPO4 with 32.67 days. The result for mean number of flowers produced per plant also showed that significant difference existed between the different sweet potato accessions at 5% level of probability across both seed and vine .The highest mean number of flowers produced per plant for seed was observed in TIS8164 with 18.33 and the least mean number of flower per plant for seed was observed TIS87/0087 with 4.60.While the highest mean number of flower per plant for vine accessions was observed in UMUSPO4 with 10.17 and the least mean number of flower produced per plant for vine accessions was observed in TIS87/0087 with 2.40.The result for pollen viability showed that ,the highest pollen viability for seed was recorded in TIS87/0087 with 4.90 and the least pollen viability for seed accessions was recorded in EX-IGBARIAN with 4.43.While the highest pollen viability for vine accessions was recorded in UMUSPO3 with 5.00 and the least pollen viability for vine accessions was recorded in UMUSPO4/TIS87/0087 with 4.67.The result of this study showed that even though flowering potentials in sweet potato Ipomea batatas.(L) Lam was observed to be low, some of the accessions used showed some potentials that could be used in improving seed set, thereby increasing the availability and varieties of planting materials of sweet potato.

Keywords: *Pollen viability, Flowering, seed settings, sweet potato Ipomea batatas. (L) Lam.*

INTRODUCTION
Sweet potatoes *(Ipomoea batatas* (L) Lam) belongs to the family Convolvulaceae (morning glory) family, the crop is originated in the central or south American low land with subsequent dispersed to North America, Europe, Africa and Pacific between 15th and 20th century (Carperna, 2009). The crop is a dicotyledonous, perennial vine, cultivated as an annual, crop, sweet potatoes is a crop that is very well suited to local growing conditions especially during our prolonged dry season. When growing with irrigation, high yields are obtainable and root quality is good, poor yield and quality associated with low ambient and soil temperatures are problems for southern growers, which can provide a market opportunity for okay grown crops (Gruneberg *et al.,* 2004). Sweet potatoes is an important food security crop grown in many of the poorest regions of the world mainly by women for food and as a source of family cash income (Peter, 2004) (Anginyah *et al*., 2001). The tuberous roots and leaves of sweet potatoes is an excellent source of carbohydrate, protein, iron, vitamin A, C and fibre. Sweet potato vine has crude protein content ranging from 16 to 29% on dry matter basis which is comparable to leguminous forages increased milk yield (Estes, 2009). The fresh tuberous root contains 80 to 90 % carbohydrate of dry matter (Elston, 1963).

The sweet potato is mainly propagated by vine cuttings, planted on mounds or ridges and in single or double rows (Siddigue *et al.*, 1988). It is one of the world's most important food crops due to its high yield and nutritive value. Its importance in starch, alcohol, livestock, pharmaceutical and textile industries cannot be over emphasized (Tewe *et al.*, 2003). The orange-fleshed varieties with high β-carotene content have become very important in combating vitamin A deficiency especially in children. The cultivation and production of sweet potato is on the increase in Nigeria. The crop has moved up from a minor crop status to an enviable position of being the fourth most important root and tuber crop after cassava, yam and cocoyam (Tewe *et al*., 2003). Survey reports placed Nigeria, as the number two producer of sweet potato in Africa with an annual production output of 2.5 million Mt in 2004 from 149,000 Mt in 1961 (FAO, 2004). The ravaging effect of diseases and pests have also been noted, even as emphasis is also shifting to include such important traits like dry matter and starch content (Tewe *et al*., 2003). Clones adapted to tropical environments have been reported to flower more readily than those adapted to temperate environments, where flowering is mostly artificially induced (Onwueme, 1978). This study was carried out to evaluate the seed setting pattern of sweet potato (*Ipomoea batatas* (L) Lam) propagated by vine and seed in Lafia, Nasarawa State.

MATERIAL AND METHODS

The experiment was carried out at the research and experimental plot of the botanical garden of Federal University of Lafia, Nasarawa State, Nigeria, located on latitude 8°28N and longitude 8°23E.(NIMET,2010). Land preparation was done manually planting will be done using the standard potatoes planting method. Weeding was carried out manually once at two weeks interval after planting using hoe. The vine and seed of potato were collected from the National root crops Research Institute (NRCRI) Umudike, Abia State, Nigeria.

The experiment was laid out in a Randomized complete block design (RCBD) with three (3) replications. Plots measuring 3m x 3m with each plot consisting of three (3) rows each measuring 3m x 0.7m with inter row spacing of 0.5m and intra row spacing of 1m will be used giving a total plot size of 399m^2**.** Data was collected in the field from randomly selected and tagged plant from each plot. The following parameter will be observed:-Number of Days to Onset of Flowering, Number of Flowers Per Plant, Pollen Viability.

Data collected were subjected to ANOVA (Analysis of Variance) and LSD method at 5% level of probability to compare difference among treatment using Genstant discovery version 3 statistical software.

RESULTS

Analysis of variance (ANOVA) result for the mean number of days to onset of flowering showed that significant difference exist between the different accession of *Ipomea batatas* (L) Lam at 5% level of probability as shown in Table 1.The earliest number of days to onset of flowering was observed in Tis8164 with 54.33 days followed by Tis87/0087 with 55.67days, Umuspo4 with 57.00days, Ex-igbarian with 58.00days while Umuspo3 accession did not flower as shown in Table 1.

Analysis of variance (ANOVA) for number of flower produced per plant showed that significant different exist between the different accession of *Ipomea batatas* (L) Lam at 5%level of probability. TIS 8164 recorded the height number of flowers produced per plant with 18.33, followed by Umuspo4 with 12.53, Ex-igbarian with 7.47,TIS87/0087 with 4.60 while Umuspo3 accessions did not produced any flower with 0.00 as shown in Table1 Pollen viability ranges from 0.00 in Umuspo3 to 4.90 in Tis87/0087 and the difference was significant. Highest pollen viability was observed in Tis87/0087 with 4.90, followed by Tis8164 with 4.77, Umuspo4 with 4.77, Ex-igbarian with 4.43, pollen viability test was not conducted on Umuspo3 due to the lack of flowering as shown in Table 1. Analysis of variance (ANOVA) result for the mean number of days to onset of flowering showed that significant difference exist between the different accession of *Ipomea batatas* (L) Lam at 5% level of probability as shown in Table 1.

TABLE 1: Pollen Viability Parameters of Sweet Potato *(Ipomea batatas* (L) Lam) as Propagated by Seed

Accessions	No Days To Onset Of Flowering	Number Of Flowers Per Plant	Pollen Viability
TIS8164	54.33 ± 0.58^{a}	18.33 ± 7.37^{a}	4.77 ± 0.40^{a}
TIS87/0087	55.67 ± 7.64^{a}	4.60 ± 0.69^{a}	4.90 ± 0.17^{a}
UMUSPO3	0.00 ± 0.00^{b}	0.00 ± 0.00^{c}	0.00 ± 0.00^{b}
UMUSPO4	57.00 ± 6.08^{a}	12.53 ± 2.33^{acb}	4.77 ± 0.40^{a}
EX-IGBARIAN	58.00 ± 0.00^{a}	7.47 ± 0.5^{b}	4.43 ± 0.23^{a}
LSDS	7.96	6.32	0.52

Analysis of variance (ANOVA) for number of flower produced per plant showed that significant different exist between the different accession of *Ipomea batatas* (L) Lam at 5%level of probability. Umuspo4 recorded the height number of flowers produced per plant with 10.17, followed by Tis8164 with 5.97, Umuspo3 with 5.33, Ex-igbarian with 3.87 while Tis87/0087 with 2.40 as shown in Table 2. Pollen viability ranges from 4.67 in Tis87/0087 and Umuspo4 to 5.00 in Umuspo3 and the difference was significant. Highest pollen viability was observed in Umuspo3 with 5.00, followed by Tis8164 with 4.80,Umuspo4 ,Ex-igbarian with 4.77, Umuspo4 with 4.67,Tis87/0087 with 4.67 as shown in Table 2. The earliest number of days to onset of flowering was observed in Umuspo4 with 32.67days followed by Tis8164 with 42.33days, Umuspo3 with 59.00days, Tis87/0087 with 61.00days while Ex-igbarian flowered late with 63.33 as shown in Table 2.

TABLE: 2 Pollen Viability Parameters of Sweet Potato *(Ipomea batatas* (L) Lam) as Propagated by Vine

Accessions	Number Of Days To Onset Of Flowering	Number Of Flower Per Plant	Pollen Viability
TIS8164	42.33±4.16[a]	5.97±2.40[a]	4.80±0.17[a]
TIS897/0087	61.00±5.20[b]	2.40±1.06[b]	4.67±0.35[a]
UMUSPO3	59.00±8.66[c]	5.33±6.1[a]	5.00±0.00[b]
UMUSPO4	32.67±2.31[d]	10.17±2.39[c]	4.67±0.35[a]
EX-IGBARIAN	63.33±0.58[b]	3.87±1.95[d]	4.77±0.40[a]
LSD	9.10	3.33	0.54

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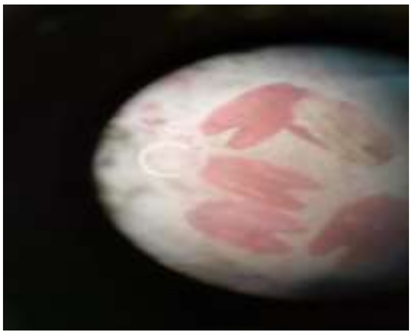
Plate 1: Before the onset of flowering of sweet potato

Plate 2: Showing the onset of flowering in sweet potato



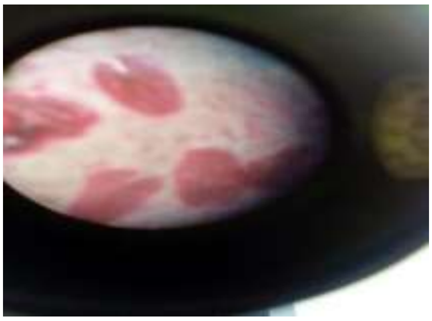


Plate 3: Showing sterile pollen on the microscopic side grains on a microscopic slide

Plate 4: Showing viable pollen

DISCUSSION

Variation in the number of days to onset of flowering amongst accessions could be attributed to both genotypic and environmental factors and influence. Robert *et al*., (1996) reported that when the critical photoperiod is exceeded, flowering is delayed, and the delay increase with photoperiod, until ceiling photoperiod to attained.in photoperiod longer than the ceiling, there is no response to either the number of days to onset of flowering or the number of flower per plant. In this study of the accession propagated by seeds it showed that Ex-igbarian took longest time to flower at 58days while Umuspo3 of the seed accession did not flower all through the replications in the studies. While for the accessions propagated by vine showed that Ex-igbarian took the longest time to flower at 63.33days. This can be describe as having poor sensitivity to photoperiod, (Chung and Myeong, 1996). Accessions that flowered late took a longer time to transit from the vegetative to reproductive phase.

Variations in the mean number of flowers per plant and rate of flowering depend on the length of time in which new flower are produced as well as length of life of individual flower (Reiger and Sedgley, 1996). For the accessions propagated by seedTis8164 with 18.33 produced the highest number of flower per plant. While for the accession propagated by vine Umuspo4 with 10.17 produced the highest number of flower per plant.

Pollen viability accession propagated by seed ranges from 0.00 in Umuspo3 and 4.90 in Tis87/0087 while pollen viability for accession propagated by vine ranges from 4.67 in Tis87/0087/Umuspo4 and 5.00 in Umuspo3.this study indicate that pollen viability is low. The high temperature condition in Lafia Nasarawa state might have contributed to low pollen viability of the different sweet potato accessions across vine and seed. Mes and Menge (1954), also reported that extreme temperature conditions of the environment effect pollen viability of crop plants.

CONCLUSION

Result of this study showed that flowering potentials of sweet potato *(Ipomea batatas* (L) Lam)in Lafia is extremely low, thus resulting in negligible or no seed set during cropping season, thereby making it difficult to propagate sweet potato by using seedws.it is therefore recommended that more work be carried out on the improvement of sweet potato *(Ipomea batatas* (L) Lam) through seed in Lafia, Nasarawa State.

RECOMMENDATIONS

i- Based on findings of this research, the vine accession was seen to have performed more than the seed accession in this research, so it is therefore recommended that the vine accession should be adopted for crop improvement in *Ipomea batatas* (L) Lam in Lafia Nasarawa State.

ii - It is also recommended that more advanced research be carried out to explore the potentials for seed production on *Ipomea batatas* (L) Lam in Lafia Nasarawa State.

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CONSUMPTION LEVEL OF ORANGE FLESHED SWEET POTATO PRODUCTS AMONG RURAL HOUSEHOLDS IN ABIA STATE, NIGERIA

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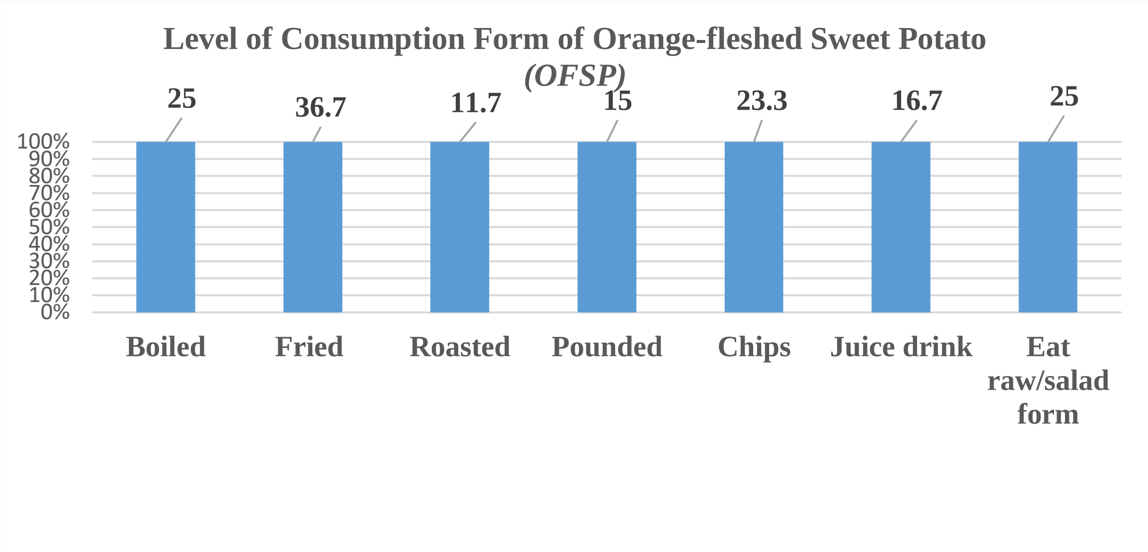
ABSTRACT
The study assessed the level of consumption of Orange Fleshed Sweet Potato (OFSP) products among rural households in Abia state. Using random and purposive sampling methods, a sample size of 60 respondents who had received the OFSP in the study area was chosen. Data were gathered by questionnaires, interviews, and Focus Group Discussions (FGDs) and analyzed using descriptive statistics. Results show that consumption level of OFSP was higher in fried, boiled and eating it raw and in salad forms while majority consume the products because of its colour, crispness, and taste. Absence/scarcity of the products in local markets, dearth of information on OFSP and scarcity of vines were the most serious constraining factors to consumption of the products in the study area. Therefore, promotional activities such as awareness campaigns and nutritional information showcasing the potentials of OFSP products is highly recommended. This would increase intake and help to attain the goal of eliminating vitamin A deficiency (VAD) in Nigerian.
Keywords: *Consumption, OFSP, Rural Households*

INTRODUCTION
Orange-fleshed sweet potato (OFSP) is an improved breed of sweet potato (*Ipomea batatas*) that is cultivated in tropical and semi-tropical regions of the world for food and source of income especially among the rural dwellers. Orange-fleshed sweet potato varieties are rich in beta carotene, (a precursor of vitamin A) and with proven high content of this nutrient, it is considered a key crop to combat vitamin A deficiency (VAD) problem in the Sub-Saharan Africa (Afuape *et al*., 2015). As reported, millions of Nigerians, irrespective of age, sex or geographical location consume less vitamin A than the body needs while women and children remain the most vulnerable, resulting in reduced immunity, impaired vision, and, in some cases, even blindness and death (Egesi *et al*., 2014; Njoku*etal*,2013). Vitamin A deficiency retards growth increases risk of disease, and can cause reproductive disorders (NRCRI, 2014 and Onyeneke *et al*., 2018). Since the presence of β-carotene in the new sweet potato could improve the nutritional status of the consumers, there is therefore a need to evaluate the consumption level of these newly bred crops. Obviously, the consumption of this β-carotene can help in combating vitamin A deficiency, which is a serious public health problem in many parts of the World today and formulation of different food products from the crops will also help to enhance its consumption (Ayinde *et al*., 2016 and Ilona *et al*., 2017). This study, therefore, specifically assessed the level of consumption form of orange sweet potato *(OFSP)*; assessed the consumer preference and acceptability of OFSP products; determined the factors influencing consumption of OFSP products and identified constraining factors to consumption of OFSP in the study area.

METHODOLOGY
The study was carried out in Abia State located in south-east Nigeria. A multi-stage sampling technique was used to select respondents for the study. Ohafia and Umuahia agricultural zones were purposively selected for the study. The reason for purposive selection is because OFSP vine has been introduced in those locations through suitable training. The second stage involved random selection of two (2) blocks from the chosen agricultural zones making a total of four (4) blocks. The third stage involved random selection of three (3) circles from each of the chosen blocks to give a total of twelve (12) circles. In the fourth and last stage five (5) respondents were randomly selected from each circle to give a total of sixty (60) respondents. A structured questionnaire and FGD were used to interview the respondents, in all sixty (60) respondents made up the sample size for the survey. Data collected were analysed by means of descriptive statistics and mean count.

RESULTS AND DISCUSSION
Level of consumption form of orange fleshed sweet potato *(OFSP)*

The result in Figure 1 showed that 36.7% of the households consume in fried form, 25.0% boiled while 25.0% eat it raw/slice as salad and consume. Furthermore, 23.3% of the households consume OFSP in form of chips, 16.7% as juice, 15.0% in pounded form while 11.7% in roasted form. This result implies that consumers mainly and frequently consume OFSP in fried, boiled and chew it raw. It is very important to note that processing the OFSP into value added products such as chops, bread, chin-chin, cake, drinks, etc. is likely to boost frequency of consumption in Nigeria, particularly among children. This study agrees with the report of Amadi *et al*., (2019).



*Source: field survey, 2021 *Multiple responses recorded*

Consumers' Preference and Acceptability of OFSP Products

The result in Table 1 showed that majority of consumers in Abia state prefer and extremely liked consuming OFSP because of its orange colour, crispness and taste of the raw/salad, boiled and fried OFSP. This implies that the consumers' preference and acceptability of OFSP products was moderate. This study conforms to the findings of Oparinde, *et al*, (2017), who said that the yellow color of the root and its processed products is seen as evidence of the presence of vitamin A and is liked by consumers. Amadi *et al*., (2019) reported that to aid in acceptance, public relations tools need to be implemented to increase consumer demand and inspire positive attitudes surrounding new products made from bio-fortified crops.

Table 1: Distribution of respondents based on consumption preference and acceptability of OFSP.

Consumption Preference of Orange-fleshed Sweet Potato	Frequency (n=60)	Percentage (%)
Boiled OFSP		
Colour	31	51.7
Taste	15	25.0
Mouth feel	12	20.0
Fried OFSP		
Crispness	28	46.7
Colour	29	48.3
Taste	18	30.0
Roasted OFSP		
Colour	21	35.0
Taste	13	21.7
Mouth feel	13	21.7
Bounded OFSP		
Texture	13	21.7
Colour	21	35.0
Mouldability	11	18.3
Raw/Salad OFSP		
Crispness	24	40.0
Taste	16	26.7
Colour	21	35.0
Drinks/Chips OFSP		

Palatability	17	28.3
Colour	26	43.3
Taste	20	33.3

Source: Field survey, 2021 *Multiple responses recorded

Factors influencing consumption of OFSP Products

The overall factors influencing respondents' consumption of OFSP products in Abia state was high with a grand mean score of ($\bar{x}$ = 2.3) which is higher than the decision mean cut-off of 2.0 (Table 2). The result shows that the factors influencing respondents' consumption of the products showed that they affirm that the products have health/nutrition value/information ($\bar{x}$ = 2.4), vitamin A content ($\bar{x}$ = 2.3), high quality products ($\bar{x}$ = 2.1), palatability of the products ($\bar{x}$ = 2.2) and simple to process ($\bar{x}$ = 2.4). The result further showed that OFSP products is not always available and accessible in some of the study area. This finding is in line with Bouis *et al.*, (2017), HarvestPlus (2016), and Ilona *et al*., 2016) that information of the nutrition and health benefits content remains an important factor and its instrumentality in the integration of bio-fortified food to people's diet, thus increasing adoption and consumption for good vision and strong immune system.

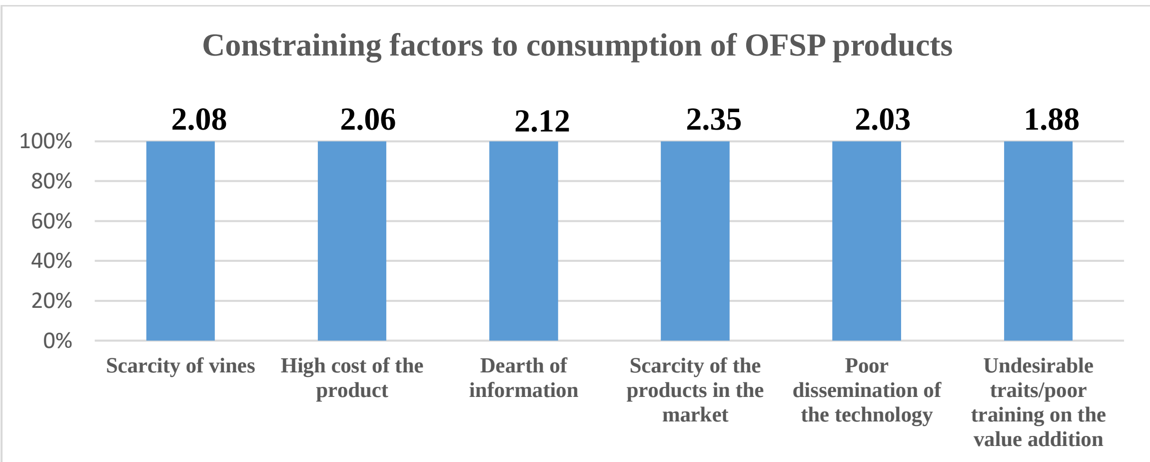
Table 2: Mean responses of the respondents on factors influencing their consumption of OFSP products.

Variables	HI	LI	NI	Total	Mean
Health/nutritional value	33(99)	18(36)	9(9)	144	2.4
Vitamin A content	29(87)	21(42)	10(10)	139	2.3
The products are of high qualities	25(75)	18(36)	17(17)	128	2.1
The products are palatable	21(63)	27(54)	12(12)	129	2.2
The products are simple to process	27(81)	29(58)	4(4)	143	2.4
The products are available and accessible	11(33)	32(64)	17(17)	82	1.4
Grand mean					**2.3**

Source: ***Filed survey 2021 *HI=High Influence, LI=Low Influence, NI=No Influence.***

Constraining factors to consumption of OFSP products

Figure 2 shows the mean scores of constraining factors to consumption of OFSP and the result shows that the overall grand mean score ($\bar{x}$ = 2.03) which is greater than the decision mean cut-off of 2.0 was below the decision mean cut-off. The result shows that absence/scarcity of the products in the local market, dearth of information on updates on the technology from the developers in rural areas, scarcity of vines, high cost of the products and poor dissemination of the technology were the most serious constraints to the consumption. This implies that the extension programme needs to intensify efforts in technology deliveries and updating in the rural areas. These factors are retrogressive to the total utilization goal of the vitamin A variety. Some factors militating against adoption of biofortified crops and products, according to (HarvestPlus, 2016 and Onyeneke *et al*., 2018) include: marketability, price fluctuation, costs related to the distribution of new vitamin A varieties in places, cropping patterns and the multi-cultural nature of the targeted populations in Nigeria whereby some people still mix the cropping of these improved varieties with the local ones, thus reducing its multiplicity ability.



Source: ***Filed survey 2021***

CONCLUSION

The study concluded that consumption of OFSP in fried, boiled and eating raw/ salad forms were the most consumed forms among the households. The consumers preferred and accepted the products mainly because of the orange colour, crispness and taste. It was also revealed that health/nutrition value, vitamin A content, simple to process and high quality of OFSP were the major factors that influenced consumers while absence/scarcity of the products in local markets, dearth of information on OFSP and scarcity of vines were the most serious constraining factors to consumption of the products in the study area. Therefore, promotional activities such as awareness campaigns and nutritional information showcasing the potentials of OFSP products as well as disseminating more vines to users are highly recommended. This will boost consumption level and achieve the focus on eradicating vitamin A deficiency (VAD) among rural households in Nigeria.

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COMMERCIALIZATION OF IMPROVED CASSAVA SEED IN NIGERIA: THE EXPERIENCE OF NATIONAL ROOT CROPS RESEARCH INSTITUTE (NRCRI) IN BASICS-II PROJECT

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ABSTRACT
National Root Crops Research Institute (NRCRI) Umudike in collaboration with International Institute for Tropical Agriculture (IITA) Ibadan and Catholic Relief Services (CRS) midwifed the cassava seed entrepreneurship model with the aim of commercializing cassava seed in Nigeria. NRCRI is involved in three project States namely Abia, Akwa Ibom and Imo. A paradigm shift from the informal seed distribution system that is characterized by low adoption, absence of varietal traceability, seed sharing and low incomes to a formal seed system where seed sourcing is organized, seed quality is assured and certified. The farmers have access to land with more than one hectare, willingness to extend cassava seeds to other farmers and abiding by National Agricultural Seed Council (NASC) regulations, major source of foundation seed was *from NRCRI. Commercialization of cassava seed offer disease free planting materials to farmers, improved income of the Cassava Seed Entrepreneurs (CSEs), create employment opportunities, supply of high-quality improved cassava varieties, provide substantial new income-generating opportunities and increased adoption level of improved certified cassava varieties. Among the challenges to cassava seed commercialization were bottle necks in seed certification that led to introduction of licensed seed inspectors. It is therefore recommended that the project should popularize and upscale the released varieties through market day promotions, demonstration farms and product lunch for greater achievements.*
Keywords: *Commercialization, Improved Cassava Seed, NRCRI and BASICS-II Project.*

INTRODUCTION
Cassava (*Manihot esculenta*) is a staple food for many people in large parts of Tropical Africa, South America and Asia and over 700 million people in western and central Africa with an average consumption of approximately 500 calories per day (Ogbuokiri *et al.*, 2015). It is considered the most important tropical root crops providing food and income to over 30 million farmers, processors and traders (Apata, 2019). Cassava is cultivated in almost all agro-ecological zones in Nigeria. Over 90% of cassava produced in the country is consumed locally with less than 10% utilized for industrial purpose. Cassava represents the largest crop by area and production volume in Nigeria. Cassava has received the greatest attention in terms research leading to great improvement in yield and nutritional quality (Eke-Okoro, 2011). Achieving increased yields starts with the selection of high quality planting materials and adopting proper planting procedures. It is propagated by stem cuttings which must behandled properly for good sprouting and establishment. The importance of cassava to resource-poor farmers in Nigeria cannot be overemphasized. Cassava has played and continues to play a remarkable role on the agricultural sector of Nigeria, it can survive droughts, inexpensive, resistant to pests and easy to grow. Cassava has a special capacity to bridge the gap in food security, poverty alleviation, and environmental protection (Clair and Etukudo, 2000).
Seed systems are governed by both formal and informal rules that impact on the level of influence and participation for both men and women and their ability to benefit from the system (Galie, 2013). In Nigeria, the seed industry is still developing especially for crops like cassava whose botanical seeds are not consumed or popularly used for planting. Although production of cassava is dominated by over 6 million families, typically smallholders with an average farm size of 0.5ha, over 90% of these farmers use the informal seed system by recycling stems from the previous harvest (Sahel, 2016). This informal seed system describes the process where farmers acquire seeds from traditional sources based on seed exchange or gift or purchase from other farmers and local markets. Comparatively, the informal seed system is not characterized, regulated and supervised by any private or public institution but dominated by smallholder farmers. Within this informal system, seed varieties are

selected, multiplied and distributed at the local level based on traditional knowledge. In most cases, smallholder farmers combine different crops and manage to maintain the genetic diversity usually consisting of the traditional landraces. In contrast to the informal seed distribution system, the formal seed system notably ensures the development and distribution of improved seed varieties through a series of interdependent activities (Ewuziem and Asumugha, 2018). The existing seed systems have operated at a local scale, based on diverse farmer practices for selection, multiplication and exchange of planting material.

Building an economically sustainable, integrated cassava seed system (BASICS) is a project that seek to help Nigerian cassava producers reach the potentials of 45MT/ha by involving the development of a commercially sustainable cassava seed value chain based on the purchase of quality seed by farmers. To further ensure the sustainability of the project, vibrant and profitable cassava seed entrepreneurs are encouraged to venture into the seed business. These seed businesses will provide healthy seed of more productive varieties leading to adoption of new varieties to improve productivity and food security, increase incomes of cassava growers and seed entrepreneurs, and enhance gender equity. The Cassava seed entrepreneurs (CSEs) model is a distinctive pathway of seed delivery in, Abia, Imo and AkwaIbom States, to help develop a network of community based seed enterprises. These CSEs source breeders' seed of improved varieties of cassava from Umudike Seed Company, NRCRI Go, Seed Company IITA and the Foundation Seed Producer (FSPs) to multiply and sell to farmers in their vicinity. The strategy is to carefully select grass root entrepreneurial seed producers in the project target areas as CSEs using laid down criteria to ensure compliance requirements for certification by the National Agricultural Seed Council of Nigeria. Commercialization of cassava seed is the process by which cassava seed entrepreneurs produce surpluses which can be sold in the market and thus increase their market participation (Adamu, 2021). In line with policy thrusts, the Federal Government of Nigeria in recent times has consistently promoted the increasing commercialization of agricultural production through its different schemes, policies and programmes. The commercial seed production model based on cassava seed entrepreneurs (CSEs) distributed in a hub-and-spoke model with quality control oversight is a profitable and sustainable model to reach cassava seed farmers (Legg *et al.*, 2022). Commercially sustainable seed systems for cassava, which deliver certified seed of improved varieties, offer great potential benefits to farmers, including:

i. increased productivity resulting from low disease and pest levels.
ii. provides an assurance that what they pay for is what they get.
iii. commercial seed systems that supply high quality products also provide substantial new income-generating opportunities for farmers.

Furthermore, structured commercial cassava seed systems that provide quality assurance may enhance dissemination of improved varieties to smallholder farmers and inform breeding programs on varietal demand and trait preferences, which in turn will result in a more dynamic and productive cassava economy (Legg *et al.*, 2022)

NRCRIs Experience in Commercialization of Cassava Seed in BASICS Project

i. NRCRI is involved in three project States namely Abia, AkwaIbom and Imo.
ii. Capacity building given to CSEs on good agronomic practices, Techniques and handling of SAH (Semi-Autotrophic Hydroponics) materials - Modern Technique in producing clean planting materials through Biotechnology, Business & Enterprise development/strategies for stems & roots, and Integrated Pest and Disease Management. Pest Control-Types & control measures Disease and Record Keeping & Management, cost of production for cassava stems per hectare.
iii. A paradigm shift from the informal seed distribution system that is characterized by low adoption, no varietal traceability, seed sharing and low incomes to a formal seed system where seed sourcing is organized, seed quality is assured and certified.
iv. Stakeholder synergy consolidating.
v. Farmers organization and cooperatives encouraged.
vi. The farmers have access to land with more than one hectare.
vii. Major source of cassava seed from NRCRI Umudike.
viii. Commercialization of cassava seed increased and offer great benefits to Cassava Seed Entrepreneurs (CSEs), including: increased productivity resulting from supply of high-quality improved cassava varieties.
ix. Registration of CSEs on the Cassava Seed Tracker.
x. Willingness to extend disease free cassava seeds to other farmers and abide by National Agricultural Seed Council (NASC) regulations.
xi. Certification intensified, Licensed Seed Inspectors (LSIs) came on board.
xii. Willingness to pay for cassava seed increased.
xiii. Provide substantial new income-generating.
xiv. Create employment opportunities.
xv. Demand for preferred varieties increased.
xvi. Adoption level of improved certified cassava varieties increased.
xvii. Business opportunities of the seed entrepreneurs expanded.

xviii. Seed companies in cassava emerged.
xix. Association of cassava seed entrepreneurs at Zonal, State and National levels are existing.

Challenges Faced by the CSEs from NRCRI Experience

The challenges faced by the cassava seed entrepreneurs are high cost of transportation, low mechanization and use of tractor, theft of certified cassava seeds from the farm, menace of cassava seed farm by cattle, bottle necks in seed certification that led to introduction of licensed seed inspectors. This finding is in line with the report of Anyaegbunam *et al.* (2022), that constraints faced by the seed entrepreneurs were cattle menace, inadequate finance, low level of mechanization, high cost of inputs, poor road network and low patronage.

CONCLUSION AND RECOMMENDATION

NRCRI experience in commercialization of cassava seed of BASICS Project spread through informal and formal stages of seed system in the Zones. Commercialization of improved cassava seed suppled high quality products, increased production, and provided substantial new income-generating opportunities for farmers and business potentials of the CSEs. Among the challenges to cassava seed commercialization were bottle necks in seed certification that led to introduction of licensed seed inspectors, high cost of transportation, low mechanization, theft of certified cassava seed from the farm, and menace of cassava seed farm by cattle. It is therefore recommended that the project should popularize and upscale the released varieties through market day promos, demonstration farms and product lunch for greater achievements.

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LIVESTOCK PRODUCTION AS SUSTAINABLE PATH TO NIGERIA'S ECONOMIC RECOVERY AND FOOD SECURITY - A REVIEW

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ABSTRACT
Livestock production plays a significant role in rural livelihoods and the economies of developing countries like Nigeria. They are providers of income and employment for producers and others working in, sometimes complex, value chains. They are a crucial asset and safety net for the poor, especially for women, and they provide an important source of nourishment for billions of rural and urban households worldwide. These socio-economic roles and others are increasing in importance as the sector grows because of increasing human populations, incomes and urbanization rates. To provide these benefits, the sector uses a significant amount of land, water, biomass and other resources and emits a considerable quantity of greenhouse gases. Managing the required intensification, food insecurity and the shifts to new value chains is also essential to avoid a potential increase in food-borne and other diseases. Food security and growth in agricultural output depends on technological usages, which enhances the productive capacity of the agricultural sector. The study explored the challenges of animal production and food security in Nigeria with an attempt to explore the current trends in food production as it relates to food security in Nigeria.
Keywords: *Livestock production, sustainable path, economic recovery, food security*

INTRODUCTION
The relationship between agriculture and development, especially in Sub-Saharan Africa, cannot be overemphasized. We are at a moment in time where our actions could be decisive for the resilience of the world food system, the environment and a billion poor people in the developing world, let alone for the fate of our planet (Olaoye, 2014). The society has realised that there are major pressures on the world's food and ecological systems, where changes to the biogeochemical cycles on a global scale may be irreversible and where new drivers, such as climate change, are likely to exert additional pressures for feeding 9 billion people in the future in a sustainable manner. The demand for animal products is rising concurrently, particularly in developing nations, which puts further strain on the world's natural resources. In West Africa, Nigeria is a key centre for the consumption of animal products. It is also one of the major producers of livestock in the region (Zougmoré *et al.*, 2016). For Nigeria and the livestock-producing neighbouring Sahel nations, meeting the rising domestic demand and gaining access to these booming markets are crucial economic issues. The majority of countries in the globe are currently dealing with enormous population growth and environmental problems, which have put their respective countries' food security in danger (Huang and Ukpong, 2019). There needs to be a proportional increase in food production to feed this expanding population.
Food is a vital requirement for human survival since it provides the essential nutrients required for the body's general function. According to the Food and Agriculture Organisation (FAO), food comprises grains, oils, and

products from animals (Tubiello *et al*., 2013). However, this definition now includes other goods including sugar, fruits, vegetables, legumes, roots, and tubers (Crentsil and Ukpong, 2014).
According to Inyeinyang *et al*. (2019), one of the aspects of poverty is food insecurity, which includes both the availability and access to food (supply and entitlement). The inability to buy enough food that may be regarded adequate to give the necessary amount of protein and energy needed by the human body within a specific time can be characterised as food poverty, and livestock production is a contributing component to these needs for high-quality food. Depending on the degree of income, the contribution of livestock varies from home to household. The consumption of livestock protein and other animal products like milk, meat, and eggs also varies from household to household because some livestock keepers sell their stocks for money in order to buy food grains, cereals, and vegetables, while others keep the smaller mammals for food (Inyeinyang *et al.*, 2019). This provides some proof of how crucial agriculture is to economic growth. However, without economic growth, continuous economic progress is impossible. According to the World Bank (2006), high levels of poverty will result in slow economic growth, and low levels of poverty would result in fast economic growth. As a result, sustained economic development requires economic growth (Akanbi and Du Toit, 2011). This essay examines the benefits and drawbacks of animal production as a long-term strategy for Nigeria's economic growth and food security. Additionally, it covers important aspects that will probably determine how much the industry contributes in the future to economic development, environmental preservation, and food security. Our investigation on the contributions of agriculture to economic growth, as measured by Gross Domestic Product (GDP), in Nigeria is motivated by the knowledge that economic growth is essential for sustained development.

The current state of the livestock sector in Nigeria

The animal husbandry sector in Nigeria in its current state is unable to ensure the self-sufficiency of the population in animal products. The nation possesses abundant animal resources, including cattle, sheep, goats, and poultry, as well as beaches and fishing and aquaculture reservoirs, but these resources are insufficient to support the population's needs, Dixon *et al.*, 2001). The population of Nigeria is growing faster than the population of farm animals, according to research, and despite positive dynamics in the production of meat and fish, Nigeria's external dependence on imports, whose share in livestock production is roughly 20%, has not yet been overcome. In addition, Nigeria is the most densely populated country in Africa, with over 200 million inhabitants in 2022, and it is predicted that by 2050, that figure will have nearly doubled to 402 million (Adegbeye *et al.*, 2020). As a result, there will be a greater demand for food products with an animal origin. Given the situation, it is crucial to pay attention to the issues preventing the full development of animal husbandry, as this is the most significant step towards enhancing the nation's food security, enhancing the diet of the populace, and modernising the agricultural sector of the economy. The conflicts between farmers and pastoralists, which not only result in human and animal losses, disrupt population peace, and jeopardise the nation's food security, should receive special attention as the principal barrier to the expansion of animal husbandry (Abdulyakeen, 2022).

The Livestock Sector and its Contributions to Nigerian Economic Development

Livestock is a significant component of Nigerian agriculture and plays a significant role in the country's economy. In small-scale farming systems throughout the developing world, animals play a significant role in sustaining livelihoods. In these systems, livestock and crops frequently surround a dynamic interface. Animals are crucial to human welfare everywhere in the world.

• The provision of food and animal products used for food by people in many parts of the world is the most significant use of livestock. Meat and milk are two examples of animal products that are utilised as human food; they may also be found in livestock feed. Blood meal and bone meal are sources of protein and minerals, respectively. All types of families, both in rural and urban regions, can obtain nutritious food from livestock. For a very long time to come, bullock power will probably continue to be the primary source of draught power for agricultural operations and the transportation of agricultural products to local markets.

Socio-economic Nigeria's macro livestock industry is important.

Gross domestic product (GDP) growth and income generation are both a result of the high demand for livestock food and goods, which has aided farmers in growing their businesses. Farmworkers are given employment options, and a wide range of livestock industry knowledge and services are provided. Research and development efforts are strengthened in the areas of antimicrobial resistance, food safety, and drug toxicology. Cattle, donkeys, camels, and horses are used as draught animals by local farmers for land preparation (tilling, ploughing) in agricultural crop production. This supports public health and offers pertinent information for economic planning and policymaking in the areas of financing, health, and agriculture. Additionally, this guarantees ongoing breed line improvements for higher meat and milk yields to fulfil the rising food demands of Nigeria's population (Shi *et al.*, 2022).

Enhancing livelihoods and eliminating poverty among farmers and herders. These represent a number of additional payments to the households engaged in agriculture (Kemp *et al.*, 2013). Livestock are significant sources of investment and boost the value of many assets that the agricultural households could not otherwise employ. For instance, the transformation of feed biomass, such as weeds, straw, cultivated forages, public grazing areas, and surplus grains, into valuable goods like meat, milk, and eggs for consumption and/or the sale of, as well as the provision of services, such as the draught power pack (Holzworth *et al.*, 2014). These allow family members to increase the value of the work they already do on the farm.

Nigeria's Livestock Sub-Sector: Challenges and Way Forward

Nigeria animal production is facing numerous challenges with certain factors militating against successful animal production (Mgbenka *et al.,* 2016). In spite of the contribution it has made socioeconomically to the growth of the Nigerian state, the industry however, is challenged with some issues that are begging for attention which include:

1. Capital is one of the most important production elements that man is aware of. A farm that produces and processes animals needs capital to get started, and it needs capital to maintain productivity. Capital is one of the main obstacles facing the livestock business, particularly in emerging nations like Nigeria. Financial shortcomings have caused animal businesses to grow slowly, go dormant, or even be destroyed. Low-wage workers, who predominate in the animal business, are unable to meet the needs of the sector, particularly when productivity is subpar.

2. Exorbitant price of animal feeds: Animals need nutrient-rich feeds in order to fully develop and be productive. Farmers do not frequently use animal feeds, and even when they are, they are often out of reach financially. Since farmers raise animals for profit, they need to buy feed at a price that will allow them to break even as well as generate a respectable profit.

3. Animal illnesses: The livestock business continues to face a real danger from animal diseases. Animal illnesses that damage animals and consequently lower productivity pose a persistent threat to animal products. Despite numerous attempts at vaccination, viral infections like Newcastle disease and other infectious diseases are much more devastating to the chicken business.

4. Access to veterinary services (vaccines and drugs). Since the majority of animal production activities take place in rural or remote areas that are inaccessible to proper veterinary services and many of those that find the high cost of veterinary services prohibitive, then turn to readily available quacks who wreak havoc on the animal industry by using outdated vaccines, phoney medications, and incorrect prescriptions for treating diseases. Vaccines and medications of all kinds of low quality are readily available on the market nowadays and can be taken by virtually everyone.

5. Education levels of farmers: It is a well-known truth that the majority of farmers have low education levels or are even illiterate, making it challenging to use contemporary animal production techniques where traditional systems have failed or produced less profit. More graduates should be encouraged to pursue careers in animal production in order to grow the industry, which will be a wonderful idea. These graduates will introduce cutting-edge techniques for animal production that ensure the nation's food security and the growth of the industry.

6. The Government's Function: The government's unsuccessful policies are frequently detrimental to the development of the livestock sector. Politicians may impose import restrictions in an effort to support domestic sectors, but they rarely offer workable substitutes. There aren't enough good loans to maximise animal productivity, and access roads aren't built in a way that makes it easy to transport animal goods from the farm to the table. The government can assist by collecting eggs to minimise egg glut, a problem that the poultry business occasionally faces.

8. Market and storage facilities: The animal products market is essential to the industry's viability. Because most animal products are perishable and expire quickly, the market for animal production is poorly organised, and farmers frequently suffer losses rather than gains.

9. Inadequate Extension services: Extension services are essential in encouraging ethical farming and agricultural practises among our stakeholders in the livestock business. If farmers are knowledgeable about some areas of production, the cattle business can produce more than it is now doing. In order for farmers to succeed in their chosen profession and make a meaningful contribution to the economy of the country, extension specialists offer technical assistance to farmers on ways for maximising productivity as well as market-related problems.

10. Insufficient work force: The animal production business in Nigeria is suffering from a lack of labour, particularly skilled labour. In some places, one man is doing the work of several, which reduces productivity. Because of the possibility for a nation with over 200 million citizens, this is a serious worry. Nigeria will have enough individuals employed in animal production if more people are encouraged to do so.

Way forward for Livestock Industry in Nigeria

Food security and the development of any country depend heavily on animal production. It offers the following benefits to the economy:

(a) foreign exchange; (b) employment for the populace; (c) a rich source of protein, which is necessary for human nutrition; (d) prestige; (e) income for the populace; (f) draught power; (g) transportation; (h) raw materials for the clothing and shoe industry; and (i) by-products that can be used in a variety of other industries, such as the cosmetic industry.

Through commercial farming using modern techniques, livestock production has undoubtedly made a significant contribution to meeting the world's need for protein. It is also claimed to have contributed to the socioeconomic development of Nigerian state in particular, and it is anticipated to further boost development in a way that will ensure food sufficiency.

The following are the steps that Nigeria's agriculture will take to increase animal production for food security, and to strengthen the basis for decision-making, a thorough mapping of agricultural potentials is required, considering the following elements:

1. Without being able to feed and maintain the health of its population, a nation cannot be prosperous. If the government would allocate adequate funds to this subsector and promote commercial or large-scale production in order to meet the nation's food need, animal production would be a potential industry. The government should create attractive incentives to encourage young people to work in agriculture, including teaching them how to engage in commercial farming.
2. Provisions for the storage of animal products in deep freezers and other storage facilities, which are now employed with technical improvement, should be made in order to promote optimum animal productivity. Nigeria will increase its animal production with the aid of contemporary meat preservation techniques, enabling the country to engage in worldwide trade and strengthen its economy.
3. Disease prevention must be a concern for animal farmers since if one is sick, everyone is at risk. The government needs to treat this seriously and make sure that farmers have access to and can afford all of the vaccines required to help manage animal sickness. The government needs to provide subsidies for veterinary services to farmers in order for the nation to have a solid and sustainable system for raising animals.
4. They should be trained in current and sustainable business practices, and if necessary, they should be having periodic experience sharing with related counterpart both within and outside Nigeria on good practices. Moreover, considering the country's current economic situation, I think technology transfer is necessary because agriculture is the only industry that has a chance of improving the economy.
5. The federal government should introduce a programme that allows states to start animal production that is unique to each state because different states cannot produce the same livestock due to climate variability and geography.
6. To help enhance the quality and accessibility of feed materials, there is a need for further investment in the livestock sector; this requires sustained funding and support from the government and other economic partners.
7. Appropriate policies are also required to help livestock farmers, especially small-scale farmers, by offering incentives, subsidies, high-quality veterinary care, and effective breeding programmes with adequate capacity upgrading and upscaling of the existing and acceptable technologies.

CONCLUSION

Animal production has remained an important aspect of any economy. Viable agricultural programmes/policies and activities in any nation are capable of sustaining the food supply and reserves needed for the welfare of the citizens. However, in Nigeria, agriculture is despised by able bodied young men and women who do not have interest in animal production. Both the educated and non-educated roam the nooks and crannies of the cities in the urban areas looking for non-existent white-collar jobs. Because of poor attitude to animal production, there is also this disequilibrium in the production, demand and supply of food. Government must cultivate local initiatives by promoting grassroots awareness on the importance of cooperative animal husbandry and farming, which will result to greater gain of animal production, and government, should provide a platform for interaction with the local farmers in order to discover their problem and provide the needed solution.

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EVALUATION OF SWEETPOTATO (*IPOMOEA BATATAS*) SEED SUPPLY CHAIN PERFORMANCE: EVIDENCE FROM NATIONAL ROOT CROPS RESEARCH INSTITUTE, UMUDIKE, ABIA STATE, NIGERIA

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ABSTRACT
The study evaluated the sweet potato supply chain performance with evidence from National Root Crops Research Institute, Umudike, Abia State, Nigeria. The data were collected from a total of 206 sweetpotato supply chain actors who patronized the Institute during 2020 planting season using a semi-structured questionnaire. The study examined the level of customer satisfaction, vulnerability and resilience of supply chain using rating scale analysis. The results showed an average total level of satisfaction (2.12), resilience (3.05), and vulnerability (3.17) with performance evaluation of 59.20% above average indicated an efficient system of supply. The study therefore recommends effective monitoring, evaluation, and follow-up of chain actors to ensure effective performance and supply at a sustainable manner.
Keywords: *Quality, Resilience, Satisfaction, Sustainability and Vulnerability*

INTRODUCTION
One of the major obstacles to Nigeria's sweetpotato production system is the lack of a sustainable seed system, which includes a demand and supply mismatch (Namada, 2012). Understanding the current seed supply chain structure and developing it or making improvements to it becomes essential for seed entrepreneurs. According to Simchi-Levi *et al.* (2008), a supply chain (SC) is a group of individuals connected by the exchange of goods, information, and money with the aim of lowering system costs. Depending on the quantity and placement of intermediary facilities in the supply chain, the supply structure may change. The supply chain to produce sweetpotato seeds typically consists of the following facilities: supplier (from the Tissue Culture (TC) lab), manufacturer (screen house), distributor **[Decentralized Vine Multipliers** (DVMs)], and root producers (wholesaler and retailer). Each facility in the supply chain processes orders based on the information at their disposal and places order to the immediate upstream facility. The upstream facility supplies the downstream crops demand from available material. Upstream facilities point in the direction of the end provider, whereas downstream facilities point in the direction of the final consumer. Customers pick up the product from the final supply chain site in the end.

The National Root Crops Research Institute (NRCRI), Umudike at the upstream of sweetpotato supply chain has taken scientific steps to ensure continuous availability of different classes of sweetpotato seed (of all released varieties) all year long on a revenue basis. With the Institute facilities **(tissue culture laboratory, screen houses, and net tunnels), sweetpotato seeds are produced, multiplied, maintained, and sold to the downstream farmers. NRCRI supplies its seeds to categories of chain actors ranging to DVMs, seed entrepreneurs and farmers in various states of the country. However, the Institute in the past had developed the capacity of a cluster DVMs– empowered to sell commercial seeds to root producers in various communities of the states. T**hese groups of farmers and others get quality seed (certified) from NRCRI for subsequent and continuous production. This study, hence, examined the Institute's performance in the sweetpotato supply chain among its actors to primarily achieve system sustainability, with objective to ascertain the level of customers satisfaction in the supply chain; and to examine the level of vulnerability and resilience of the supply chain among the actors.

METHODOLOGY

The study was carried out from the upstream (NRCRI, Umudike) to the downstream (customers) across Nigeria who patronized the NRCRI sweetpotato seed business unit in the year 2022. Semi-structured questionnaire was used as a tool for data collection. Data was collected through face-face interaction and on-line (Google docs. survey) for those that transacted by proxy. The level of customer satisfaction was measured using a 3-point scale of Very Satisfied (VS), Satisfied (S), and Not Satisfied (NS). The study also used 6-point rating scale of Very High (VH), High (H), Moderately High (MH), Low (L), Very Low (VL), and None (N) with acceptable mean score of 3.50 for level of vulnerability and resilience of the seed supply chain. Respondents with mean score of 2.0 and above (level of customer satisfaction) and 3.50 and above (level of vulnerability and resilience) implied that they are in confirmation with the statement while respondents with mean score of less than 2.0 (level of customer satisfaction) and 3.50 (level of vulnerability and resilience) are not in use. This was calculated with equation below.

$$Xs = \Sigma fn/N \text{ ------------- } (1)$$

Where Xs =mean score, Σ = summation, f= frequency, n = likert nominal value, N= number of the respondents.
Xs=1+2+3/3 = 6/3=2. 00 (level of customer satisfaction)
Xs=1+2+3+4+5+6/6 = 21/6=3.50 (level of vulnerability and resilience)

RESULTS AND DISCUSSION

Socio-Demographic Features of the Respondents

The results in Table 1 presented the socio-demographic characteristics of the respondents. The results showed that the respondents (customers) had a mean age of about 46.00 years, educational level of 19 years, 0.75 hectare cultivated with sweetpotato and farming experience of about 2.5 years. This implied that the sweetpotato seed actors were still young and agile, had formal education; still grow sweetpotatoes for sustenance with little experience. Majority of farmers (70.9%) belonged to one or more cooperative societies, and more than half of them (53.4% and 52.4%) were female.

Table 1: Socio-demographic Variables of the Sweetpotato Seed Buyers

Variables	Mean	Std. dev.	Min	Max
Age	46.0182	9.6212	29	74
Educational level	15.8019	4.6873	5.50	16.00
Area with sweetpotato (ha.)	0.42	0.8569	0.01	4.00
Sweetpotato Farming experience	2.544	2.7078	1.00	12.00
Dummy (%)				
Sex(female)	53.40			
Membership of cooperation	70.90			

Source: Field Survey, 2022

Quantity of Sweet potato supplied

The study also measured the performance of the sweet potato seed supply system using percentage performance evaluation as showed in Table 2. The results showed that the system have an average performance of 59.2%, indicating an average performance of the system, heading toward efficient system of 100%.

Table 2: Percentage Performance Evaluation of Sweet potato Seed Chain

Quantitative measures	Number (Bundle)
Quantity of seed produced yearly	3500
Quantity of seed sold (Quantity Given to other Chain)	2075
Performance Evaluation (%)	59.20

Source: Field Survey, 2022
The system is efficient if quantity produced/sold = 1 or 100%

Level of customer satisfaction

The results in Table 3 showed the level of satisfaction by sweetpotato seed supply chain actors. The result showed that among the parameters examined, the customers were satisfied by the variety given (2.49), customer's service (2.04), production information accessed (2.28), NRCRI production environment (2.16), quality (2.50), appearance of the vines (2.50), color of the leaves (2.38), vigor of the vines (2.17), number of nodes (2.28), and packaging (2.20). The highest score from quality and appearance confirmed the study of Okoye *et al*, (2021) on the use of quality seed vines (cuttings) in any crop production as a critical factor influencing yield of that crop. Nevertheless, the actors were not satisfied with the quantity given (1.54), yield (1.95), proximity to the seed source (1.83), price (1.99), purity of the vine (1.99), and labeling (1.71) having a below mean of 2.00, the acceptable mean benchmark. This indicated that they were poor satisfaction of customers in the quality of vine at certain price, even the yield and labeling.

Table 3: Level of Satisfaction by Sweetpotato Seed Supply Chain Actors (Pooled)

Parameters	Very Satisfied	Satisfied	Never satisfied	Mean
Variety given	116(348)	74(148)	16(16)	**2.49**
Quantity	20(60)	72(144)	114(114)	1.54
Yield	54(162)	88(176)	64(64)	1.95
Customer service	68,6(222)	66(132)	66(66)	**2.04**
Production Information	80(240)	104(208)	22(22)	**2.28**
Proximity	48(144)	76(152)	82(82)	1.83
Environment	76(228)	86(172)	44(44)	**2.16**
Price	42(126)	120(240)	44(44)	1.99
Purity	42(126)	(240)	4444)	1.99
Quality	110(330)	90(180)	6(6)	**2.50**
Appearance (neatness)	128(384)	60(120)	12(12)	**2.50**
Color of the leaves	96(288)	92(184)	18(18)	**2.38**
Vigor of the vines	54(162)	134(268)	18(18)	**2.17**
Cuttings (Number of nodes)	64(192)	136(272)	6(6)	**2.28**
Packaging	58(174)	132(264)	16(16)	**2.20**
Grand mean				**2.12**

Source: Field Survey, 2022, Acceptable mean score =2.00
Figures in Parentheses are the weighted Likert frequencies.

Seed chain Vulnerability

The results in Table 4 presented the Likert analysis of sweetpotato seed (SPS) chain vulnerability among sweetpotato seed chain actors. The results of the study showed that the system was vulnerable to disease (3.64) and pest (4.13) with mean score of 3.50 and above. This implied that the sweetpotato seed have the quality or state of being exposed to the possibility of being attacked by pest and disease. The study also showed that the seed chain is not vulnerable to adverse environmental condition (3.10), unfavorable weather (3.23), weeds (2.68), drought (2.41), and others (3.01) with mean scores below 3.50, the acceptable cut-off mean.

Table 4: Likert Analysis of Seed chain Vulnerability among SPS Chain Actors (Pooled)

Vulnerability	VH	H	MH	L	VL	N	Mean
Disease	66(396)	22(110)	16(64)	34(102)	10(20)	58(118)	**3.64**
Pest	22(132)	76(380)	34(136)	64(192)	0(0)	10(10)	**4.13**
Adverse environmental condition	16(96)	36(180)	38(152)	34(102)	26(52)	56(56)	3.10
Unfavorable weather	6(36)	42(210)	26(104)	76(228)	32(64)	24(24)	3.23
Weed	0(0)	40(200)	26(104)	40(120)	28(56)	72(72)	2.68
Drought	0(0)	22(110)	16(64)	64(192)	26(52)	78()78	2.41
Others	32(360)	6(30)	0(0)	22(66)	16(32)	92(92)	3.01
Grand mean							**3.17**

Source: Field Survey, 2022
VH= Very High, H= High, MH= Moderately High, L= Low, VL = Very Low, N= None
Acceptable mean score = 3.50, Figures in Parentheses are the weighted Likert frequencies

Sweetpotato Seed Supply chain Resilience

The results in Table 5 showed the Likert analysis of sweetpotato seed chain resilience among sweetpotato seed chain actors. The results of the study showed that the sweetpotato seeds were resilient to environmentally friendly (3.63), climate conduciveness (3.59), price of the seed (3.94) and demand/supply (4.50). This was an indication that the seed chain system had the capacity to withstand or to recover quickly from shock either from increase or decrease in any of the environmental and climate conditions, price, and demand of sweetpotato seeds. This result may possibly be explained by the time of planting -raining seasons and their level of education which exposed them to knowledge of handling seed even at dry and adverse weather conditions. More so, with increase in sweetpotato seed demand, the system will still be able to supply and produce due to the quality of the production. The study also showed that the system was not resilient to disease/pest (2.28), customer in-responsiveness (2.33), Poor monitoring scheme (2.22), and government intervention (1.94), implying that system will be unable to withstand shock or to recover quickly from these parameter measurements.

Table 5: Likert Analysis of Sweetpotato Seed chain Resilience

Resilience	VH	H	MH	L	VL	N	Mean
Environmental condition	66(396)	36(180)	12(48)	10(30)	12(24)	70(70)	**3.63**
Disease/pest	12(72)	28(140)	16(64)	6(18)	32(64)	112(112)	2.28

Customer in-responsiveness	16(96)	6(30)	38(152)	22(66)	12(24)	112(112)	2.33
Poor monitoring scheme	24(144)	0(0)	26(104)	22(66)	10(20)	124(124)	2.22
Government in-responsiveness	0(0)	6(30)	40(160)	6(18)	38(76)	116(116)	1.94
Climate conducive	28(168)	22(110)	76(304)	36(108)	6(12)	38(38)	**3.59**
Price of the seed	68(408)	42(210)	18(72)	17(51)	9(19)	52(52)	**3.94**
Increase Demand/supply of root	90(540)	50(250)	7(28)	12(36)	25(50)	22(22)	**4.50**
Grand mean							**3.04**

Source: Field Survey, 2022
VH= Very High, H= High, MH= Moderately High, L= Low, VL = Very Low, N= None
Acceptable mean score = 3.50, Figures in Parentheses are the weighted Likert frequencies

CONCLUSION AND RECOMMENDATIONS

The study evaluated the performance of sweetpotato seed supply chain using evidence of NRCRI and proffered policy recommendations as implications for seed business sustainability. The study showed that the customers were generally satisfied especially in the areas of customer services, access to production information, production environment, quality, appearance, and vigor of the seed among others. The supply chain system generally showed a moderate efficient performance system of supply. The study therefore calls on the NRCRI and other seed companies on sweetpotato to work and hold tight the strengths and opportunities in the seed supply chain to sustain and mitigate the threats and weaknesses. Effective monitoring, follow-up mechanism and periodic evaluation are recommended to ensure quality maintenance, customer satisfaction, reduced chain actor’s vulnerability and increases resilience.

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EFFECT OF ADOPTION OF AGRICULTURAL EXTENSION RECOMMENDATIONS ON LABOUR FOR CASSAVA PRODUCTION IN IMO STATE, NIGERIA

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ABSTRACT
Labour is one of the production factors. It is anticipated that as adoption increases, farmer's output will increase and there will be corresponding increases in the amounts of production inputs, one of which being labour. Therefore, the purpose of this study was to determine how adoption affected the labour that resource-poor farmers in Imo State utilized to produce cassava. One hundred and eighty (180) resource-poor farmers were randomly chosen for the study using the simple random sampling technique. Regression analysis and linear correlation were used to analyse the data at a 5% level. The findings showed that adoption has no significant effect on labour. The hypothesis that there is no significant effect of adoption on labour for cassava production was accepted, while the alternative hypothesis was rejected, on the basis of the findings. Therefore, it was recommended that rural farmers should organize themselves into cooperatives to be able to meet up with the challenges of hiring farm labour.
Keywords: *Labour, Effect, Recommendations, Adoption and Cassava*

INTRODUCTION
The main goal of agricultural extension recommendations for farmers to embrace is to increase farmers' yield. Findings have demonstrated that adopting improved crop production technologies packaged by the Agricultural Extension Department increased farmers' income, allowing them to increase the purchase of production inputs while also significantly improving their crop yield (Agbarevo, 2011; Ifenkwe, 2018 and Obinne, 2020). As a result, there is a positive relationship between adoption on the one hand and yield, income and the capacity to employ more production inputs, such as agrochemicals, equipment and financing on the other. Therefore, it is anticipated that increased implementation of extension recommendations will also boost agricultural labour demand. Indeed, farm labour is typically mostly provided by the family in Africa (Dauda, 2019). Hired labour is utilized to supplement household labour. In this regard, Adegeye and Dittoh (2020) noted that although three categories of labour: family labour, hired labour and exchange labour—can be distinguished in Nigeria (Africa), family labour is the primary source of farm labour.

They added that family labour was primarily employed in Nigeria. In addition, as everyone in the family or household contributes to the development of the home lands, it includes the labour of all men, women, and children. For resource-poor farmers (small-scale farmers), who make up around 95% of the farming population, family is the primary and occasionally the only source of labour. Given that the strength of labour availability is positively connected with the area under cultivation (khan, 2019), it is well known that labour availability increases the size of the land that is put under cultivation. In a study on labour mobility for agricultural productivity, Osabo (2021) discovered that the amount of family labour greatly influenced the amount of family land needed and the intensity of agricultural activities throughout the year. He also noted that, more often than not, the availability of workers during the growing season is a bigger barrier to raising agricultural output than the availability of land. Furthermore, there is ample proof that a manpower shortage exists even when a farmer with limited resources extends the area under cultivation. As farmers adopt new agricultural technologies, this problem gets worse. Therefore, labour serves as a productivity barrier for farmers who lack access to resources. It is made worse by the fact that farmers with limited resources might want to recruit more workers to expand the area under cultivation and, as a result, boost productivity, but they might not be able to do so due to the high cost of hiring workers (Rahman, 2020). Therefore, hired labour is only used in the direst situations where family labour is severely reduced as a result of rural-urban migration (Nwankwo, 2020). It is against this background that this study was conceived to examine the effect of adoption on quantity of farm labour used by resource-poor farmers in Imo State, Nigeria.

MATERIALS AND METHODS

The study was conducted in Imo State, Nigeria. It is one of the states in South East, Nigeria. Agriculture is the major occupation of the people and the major arable crops cultivated in the area include cassava, yam, sweet potato, cocoyam and vegetables (NAERLS, 2021). The state has three agricultural zones, namely, Orlu, Okigwe and Owerri. Two blocks were randomly selected from each zone, and three circles were randomly selected from each block, making a total of eighteen circles. A total of 180 farmers were included in the sample, ten from each circle of cassava growers. Primary data were collected through the use of structured questionnaire. Utilizing linear correlation and regression analysis, data on the adoption of recommendations and labour were collected and analyzed. To obtain an adoption index for each farmer, Farmers' responses were categorized into (a) rarely adopted (b) adopted and stopped using innovation, and (c) adopted and still using innovation. To each of these categories, numerical values 1, 2, and 3 were assigned, accordingly. The subject index was calculated using the average response. With a 95% level of confidence, regression analysis and linear correlation were used to test the null hypothesis that adoption does not influence labour.

The regression equation is given by the formula: $y = a + bx$

Where:

y = labour (dependent variable)
a = intercept
b = slope
x = adoption (independent variable)

RESULTS AND DISCUSSION

The findings demonstrated that adoption had no significant effect on farm labour needed to produce cassava. This is as a result of the F-value of 1.727 being determined to be non-significant.

Table 1: The Effect of Adoption on Labour for Cassava Production

Variables	Co-efficient	Standard Error	t-value
Constant	3.645	2.532	1.439
Adoption	1.597	1.214	1.315
R	0.09706		
R-Square	0.00963		
F-Value	1.72768^{NS}		
Sampling size	180		

NS = Not significant

Therefore, the alternative hypothesis was not accepted; the null hypothesis, that adoption has no significant effect on farm labour for cassava production, was accepted. This indicated that resource-poor farmers do not require more manpower to produce cassava as a result of the use of improved cassava production technology. This is so because the family mostly supplies the labour employed in the farm. The number of farm workers needed depends on the size of the family, therefore even when adoption increases the size of the farm, labour is more or less constant. This is so because adoption does not increase the size of the family. Additionally, rural farmers organize themselves into labour unions and alternate working on one other's fields. Therefore, it was not surprising to see that adoption did not necessarily result in more people working in agriculture, even if more cultivable land would require more man-hours and man-days. In support of the aforementioned, Olayide (2020) noted that although three categories of labour: family work, hired labour, and exchange labour—can be identified in Nigeria (Africa), family labour is the most significant component of employment for small-scale (resource-poor) farmers, who make up roughly 95% of the farming population. Similarly, Mabro (2021) found that the amount of family labour available to be employed during periods of high demand for labour substantially influences the amount of family land required and the level of agricultural production. As new agricultural technology (innovation for adoption) is developed, this problem gets worse, he said. This suggests that a barrier to the adoption of such new technology or technologies is the difficulty of boosting farm manpower as required by the deployment of new technology. This is due to the positive correlation between family size and agricultural labour for farmers with limited resources, which cannot be altered by using new technologies. Furthermore, Ojidoh (2021) noted that hired labour is utilized in exceptional cases where family labour is dramatically reduced as a result of rural-urban migration, schooling, or an increase in the average age of farmers. Therefore, lack of workforce is a barrier to agricultural productivity because family labour and even child labour are still challenges (IFAD, 2020).

CONCLUSION

The study has demonstrated that adoption of improved cassava production technologies does not increase labour significantly. This suggests that even while the need for manpower may rise as a result of adoption, the number of farm labourers engaged is mostly constant. Since farming is arranged on a farm-family basis, resource-poor farmers are not prevented from increasing labour on farms when necessary; rather, they are constrained by the lack of labour or by the high cost of labour, or even both. Instead of hiring more farm labours, the additional labour requirements might be supplied by farm family members working more hours on farms. The rural-urban migration, which deprives agricultural families of labour, makes the situation worse. Government must build agro-cottage industries in order to provide basic social amenities in rural areas in order to stop the flood of rural-urban migration. The fact that the current generation of farmers is ageing out without being replaced by younger people serves as more evidence of this. However, if rural farmers can come together as cooperatives, they will be able to overcome the difficulties of employing farm labour, in order to boost farm output, this would help to alleviate some of the manpower availability obstacles.

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ANALYSIS OF PERCEIVED EFFECTS OF USE OF ICT ON CASSAVA VALUE CHAIN ACTOR (CONSUMERS) IN ANAMBRA STATE, NIGERIA

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ABSTRACT
The study examined the perceived effects of use of ICT on cassava value chain actor (consumers) in Anambra State. A structured questionnaire was utilized to collect relevant information from 100 randomly selected respondents. The study revealed that 68% of respondents were between the ages of 21 and 40, with the majority (65%) being female, and having at least, a primary education (78%). The study also found that the major perceived effects of ICT use were providing consumers with fast access to information on produce/products (x=4.11), providing information on availability of produce/products (x=4.10), and providing information on quality and condition of goods (x=4.09). Major constraints to the utilization of ICT by the respondents were inadequate durable ICT equipment/facilities with mean of $\bar{x}$= 2.20 and high cost of ICT facilities and low literacy ($\bar{x}$= 2.17). It is therefore recommended that consumers should be trained on the usage of ICT, and they should be made to understand the relevance of ICT tools in cassava value chain.
Keywords: *ICT, Perceived effects, Value Chain, Consumers*

INTRODUCTION
Cassava (*Manihot esculenta*) is a staple crop of choice across cultures and social divides in Nigerian households, widely eaten by all though processed differently. Most of the roots produced is consumed locally as traditional meals while small fraction of cassava output in the country is produced for commercial use in the livestock feed, ethanol, textile, confectionery, and food industries (Droppelmann, 2018). It is the most important crop by production, the second most important crop by consumption and it is largely cultivated by small-scaled farmers that depend on seasonal rainfall ((Sahel, 2016). Value chain is a set of activities that a firm performs in order to deliver a valuable product or service for the market (De Marchi *et al.*, 2018). Along the chain a value is added which give such product a competitive advantage in terms of quality and attracting a higher price at the market (Gereffi, 2018). In other words, a value chain is a series of activities or processes that aims at creating and adding value to an article (product) within it analyzing the opportunity cost of the new sequence along the product worth. According to Mukherjee and Maity (2015), ICT is an umbrella term that includes any communication device or application, encircling radio, television, cellular phones, computer and network hardware and software, satellite systems and so on, with the various services and applications connected with them, such as videoconferencing and distance learning. It also consists of a wide range of technologies starting from radio, television, and telephone to modern technologies like mobile phone, multimedia, internet, and satellite-based communication systems. They "old" ICT consist of the radio, television and telephone, and the "new" ICT consist of computers applications, satellite and wireless technology and the Internet.

METHODOLOGY
The study was carried out in Awka Agricultural Zone of Anambra State. A multi-stage sampling technique was adopted in selecting the respondents. Two local government areas (Awka South and Awka North) were randomly selected from the zone; two communities were selected from each of the local government areas (Nibo, Nise, Ugbenu and Achalla); twenty-five (25) cassava consumers were randomly selected from each of the communities. A total of 100 responses were returned and formed the sample size. The data for this study were obtained from primary source. Questionnaire was used for data collection and complimented with interview schedule. The questionnaire comprises of demographic characteristics, the perceived effects of use of ICT on consumers and major constraints to use of ICT. Data generated for this study were analyzed using descriptive statistics such as frequency distribution, percentage, and mean score.

RESULTS AND DISCUSSION

Socioeconomic status of the respondents

The result in Table 1 shows that greater proportions of the consumers (37.0%) were on the age bracket of 21-30. It implies that the consumers are predominantly within the productive and economically viable age, Majority (65.0%) of the consumers are female. This implies that female play a significant role in food processing for household. Majority (73.0%) of the consumers were married. It may imply that economic imperatives of family responsibility may be the driving force behind married person participating in the cassava value chain production for food security. It revealed that majority of the consumers (78%) had at least a primary education with 12% and 16% having secondary and tertiary education respectively. This implies that majority of the consumer households have basic literacy but may not be said to be adequately educated. Response on household size revealed that majority (73.0%) of the consumers had household size of between 4-6 persons. It implied that cassava is an important root crop for household food security.

Table 1: Distribution of the respondents according to their socio-economic status

Variables	Frequency	Percentage
Age		
Less than 21years	6	6
21-30	37	37
31-40	30	31
41-50	22	22
Above 50	5	5
Total	**100**	**100**
Sex		
Male	35	35
Female	65	65
Total	**100**	**100**
Marital Status		
Married	73	73
Single	19	19
Separated	1	1
Widowed	5	5
Divorced	2	2
Total	**100**	**100**
Educational qualification		
No formal education	22	22
Primary	50	50
Secondary	12	12
Tertiary	16	16
Total	**100**	**100**
Farming Experience		
1—3	12	12
4—6	73	73
7—9	15	15
Total	**100**	**100**

Source: Field survey, 2021.

Perceived effects of the use of ICT on cassava value chain actor (consumers)

Table 2 shows the perceived effects of use of ICT on the consumers. Results in Table 2 reveal that all consumers in the cassava value chain had been affected positively using ICT. The following were the major effects on consumers by the use of ICT: provides information on the unit of measurement ($\bar{x}$ = 4.24), it provide consumers with fast access to information on product ($\bar{x}$= 4.11), provide information on availability of product ($\bar{x}$= 4.10), information on quality and condition of goods ($\bar{x}$= 4.09), information on how to use a product ($\bar{x}$= 4.08), provides information on stock and supplies ($\bar{x}$= 4.07), provides information on market trends and price ($\bar{x}$= 3.91) and provides information on types of packaging ($\bar{x}$= 3.90). The implication of this finding is that consumers have real time and make value for their money. This result agrees with Baumuller (2017) who states that ICT services can facilitate the dissemination of information about availability of produce and prices as well as provide platforms for produce trading and bargaining.

Table 2: Perceived effects of the use of ICT on cassava value chain actor (consumers)

Perceived effects of use of ICT on cassava value chain actors (consumers)	Strongly agreed	Agreed	Uncertain	Disagreed	Strongly Disagree	Total	Mean
It provides consumers with fast access to information on product	250	120	24	10	7	411	4.11
Provide information on availability of product	225	140	30	10	5	410	4.10
Provides information on types of packaging	200	124	45	14	7	390	3.90
Provides information on stock and supplies	255	100	30	16	6	407	4.07
Enhance fast payment of products	230	108	45	10	7	400	4.00
Provides information on the unit of measurement	235	116	45	20	8	424	4.24
Information on how to use a product	215	140	39	10	4	408	4.08
Information on quality and condition of goods	220	144	30	10	5	409	4.09
Provides information on market trends and price	205	120	45	14	7	391	3.91
						Grand Mean	**3.65**

Source: Field survey, 2021. Cut off mean=3.00

Table 3 reveals the major constraints to the use of ICT by cassava value chain actors (consumers). The highest constraints was inadequate durable ICT equipment/facilities with mean of $\bar{x}$= 2.20, followed by high cost of ICT facilities and low literacy ($\bar{x}$= 2.17), inadequate ICT training centre ($\bar{x}$= 2.15), high cost of internet subscription ($\bar{x}$= 2.14), high cost of maintenance service ($\bar{x}$= 2.13), general lack of awareness of the important of ICTs in agriculture ($\bar{x}$= 2.12), poor network coverage ($\bar{x}$= 1.93) and erratic power supply ($\bar{x}$= 1.79). These findings agree with Godson-Ibeji (2016) who identified challenges on use of ICT as erratic power supply, poor network coverage, inadequate ICT training centre, high cost of ICT facilities, high cost of internet subscription, high cost of maintenance service and poor infrastructure.

Table 3: Constraints on the use of ICT by cassava value chain actor (consumers)

Variables	Infrastructure	Financial	Technological	Total	Mean Score
Erratic power supply	90	70	35	195	1.79
Poor network coverage	120	60	30	210	1.93
Lack of durable ICT equipment/facilities	150	80	10	240	2.20
Inadequate ICT training Centre	135	90	9	234	2.15
High cost of ICT facilities	147	76	13	236	2.17
High cost of internet subscription	156	68	9	233	2.14
High cost of maintenance service	126	96	10	232	2.13
General lack of awareness of the important of ICTS in agriculture	144	70	17	231	2.12
Low literacy level among actors	153	70	14	237	2.17
				Grand mean	**1.88**

Source: **Field survey, 2021Cut off point = 2.0**

CONCLUSION

Based on the findings of this study, it is possible to conclude that consumers had a positive perception of the use of ICT in their cassava value chain activities, as ICT is one of the driving forces that bring about development and positive change in the livelihoods of people all over the world, and particularly in Nigeria. Due to constraints such as inadequate facilities and low literacy level, ICT is still underutilized in rural regions. It is therefore recommended that consumers should be sensitized and trained on the relevance and usage of ICT, and they should be made to understand the relevance of ICT tools in cassava value chain. Coordination of efforts by government, researchers, telecoms, ICT specialists, and consumers will result in full utilization of ICT in Nigeria's cassava value chain.

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ECONOMIC ANALYSIS OF SESAME PRODUCTION IN DONGA LOCAL GOVERNMENT AREA OF TARABA STATE, NIGERIA

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ABSTRACT
The study analyzed sesame production in Donga Local Area of Taraba State, Nigeria. The specific objectives of the study were to estimate the costs and returns in sesame production; estimate the profitability of sesame production among the farmers; determine the effect of socio-economic variables on the income of sesame farmers; and identify the constraints to sesame production. Multi-stage sampling procedure was employed to select respondents for this study. A well-structured questionnaire was administered to 60 randomly selected sesame farmers. The primary data collected were analyzed using descriptive statistics, farm budgeting technique, and multiple linear regression. The study revealed that sesame production in the study area was profitable with a net farm income of ₦143, 007.63/ha and the return on Naira invested estimated at 1.60 (implying a 60 Kobo return per each Naira invested). Sesame production in the study area was faced with the problem of high cost of input, inadequate access to credit, inadequate extension services, pest and disease, continuous farmers/herders' clashes, and poor market facilities. It was recommended that sesame farmers should be encouraged to use herbicides /pesticides during their production as this aid in boasting their level of output. Sesame farmers are also encouraged to form cooperative groups to enable them to have access to loan and production inputs.

INTRODUCTION
Sesame (*Sesamum indicum L.*) is one of the important cash crops that can boost incomes of its producers and marketers which could in turn help in improving their livelihoods. It is one of the ancient oil seed crops known and use by mankind, which original area of domestication was not clear, but it is considered to have its origin in Africa and spread through West Asia, China and Japan (Rukwe *et al*., 2020). It is the eighth edible oil seeds in terms of production in the world and has higher oil content than other oil seed crops. The world over, there are about 4.8 million tons of sesame seed produced with Myanmar the largest producer while India and China are the largest exporters (Junaidu *et al.*, 2022). Similarly, sesame has been one of the cash crops produce in most part of northern Nigeria, mostly by small scale farmers which help them to acquire more income for taking care of their families as well as improving their livelihood assets. It has remained popular cash crop among farmers due to its good local and international markets potentials (Ikwuakam *et al.,* 2016).
Production of sesame seed in Nigeria has been increasing steadily because of favourable prices and demand of the commodity. Consequently, earnings of the producers and marketers are enhanced (Tahir *et al.*, 2021). Sesame seed has over 15% margin in terms of value added compared to other cash crop such as shea nuts and palm kernel.Sesame is used for various purposes such as raw materials in agro-allied industries, food, feed as well as means of generating revenue for its producers, marketers and governments. For instance, its seeds are used in confectioneries, biscuits, breads, etc., and may be baked into crackers, often in the form of sticks (Ikwuakam and Lawal, 2015). The demand for Sesame and its products is growing both at national and international levels. Therefore, there is a huge market demand for the crop. The previous status as a minor crop makes it received very little attention in aspects of research, production, processing, and marketing of the produce in the Country. Determining the benefits, and socio-economic variables and constraints influencing production of this important produce will be of great importance looking teeming population youth without job in our community. Sesame oil is of high quality free from undesirable flavour and contained antioxidant (Musa *et al.*, 2020). It is the sterling qualities that stimulate interest in the production of the crop. There are very high potentials for Sesame production

in Nigeria, but the average yield of 300kg/ha is considered too low and unattractive, hence knowing the limiting factors to boost production is imperative.

Sesame ranks the eight in the world production of edible oil seed, with higher oil content than other oil seeds. It is grown mainly for its seeds that contain approximately 50% oil and 25% protein (Gwandi *et al*., 2021). The presence of some antioxidants (sesamum, sesamolin and sesamol) makes the oil one of the most stable vegetable oils in the world, it also content nutritional and medicinal qualities, the seeds contain essential amino acid and fatty acids and a good source of vitamins. Production must be increased to take advantage of huge market potential of this crop (Madina, 2020).

Despite the benefits of sesame, less attention is directed towards its production and processing in Donga Local Government Area (LGA) for optimum benefits. Thus, improvement in the production and process of the crop could greatly help in increasing farm incomes as well as enhancing the livelihoods of the farmers and marketers of the crop in the LGA. Therefore, it is important to assess the economic analysis of sesame production to the livelihood of the farmers in the Donga LGA of Taraba State.

Objectives of the study

The broad objective was to analyze the economics of sesame production in Donga LGA of Taraba State. The specific objectives were to:

i. estimate the costs and returns in sesame production in Donga Local Government Area.
ii. estimate the effect of socio-economic variables on the output of sesame in the study area; and
iii. identify the constraints to sesame production in Donga Local Government Area

METHODOLOGY

The study area

Donga Local Government Area is one of the 16 LGAs in Taraba State, Nigeria. It is in the Southern part of the State having boundaries with Kurmi LGA at the East, Wukari LGA at the West, Bali LGA at the North and Takum LGA at the South. The LGA has 10 wards namely: Gyattaaure, Kumbo, Assibiti, Suntai, Nyita, Fada, Gayama, Mararraba, Akate and Kadarko wards. The study area occupies a total landmass of 3120km^2 with the total population of 87,021 people (NPC, 2006). The temperature of the area ranges between 28^0-38^{0}C with an annual rainfall of about 1,200 – 1,800mm per annum. The major occupations are inclined on agricultural activities such as cultivation of crops like cowpea, groundnut, maize, rice, sorghum, cassava, millet and yam and others.

Sampling technique and data collection

Multi-stage sampling procedures were adopted to select respondents for the study. The first stage involved a purposive selection of Donga LGA because of the predominant role in production and marketing activities of sesame in the area (Rukwe *et al.,* 2022). Stage two involved the random selection of five wards out of ten wards of Donga local government area. At the last stage, random sampling technique was also used to select 12 sesame farmers in the selected ward, thus, 60 respondents were selected for this study. Primary data was used and were collected through well-structured questionnaire. The data were collected in the 2022 cropping season.

Method of data analysis

Data were analyzed using Descriptive Statistics, Farm budgeting technique and inferential statistic. Farm budgeting technique was used to achieve objective (i), inferential statistic (multiple regressions) used to achieve objective (ii) and descriptive statistics such mean, frequency and percentages as may be required were used to achieve objective (iii). In analyzing the Gross margin (GM) = Gross income -Total variable costs. In this analysis, since data on fixed variables are difficult to be isolated from the variable inputs, all are variable inputs due to small nature of the farm size hence, the determined gross margin is taken to be the profit of the venture. Where: NFI = Net farm income (profit).

In determining the effect of socio-economic variables on output in sesame production, the multiple regression equation is given by $y = \alpha + \beta_1X_1 + + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \varepsilon$. Where y = dependent variable (output of sesame in kg); X_1- Age of Respondent in years; X_2 – Sex (dummy); X_3 – Marital Status (dummy); X_4 – Household size in numbers; X_5 – Experience in years; X_5 – Educational Level (dummy); X_6 – farm size in hectares; $\beta_1 - \beta_{16}$ = coefficients; α = constant term; and ε =error term

RESULTS AND DISCUSSION

Costs and returns analysis

The costs and returns associated with sesame production in the study area are as presented in Table 1. The average variable cost was ₦72, 422.37 per hectare out of which labour constituted the largest component. The result revealed that labour is the most used input among the respondents because it has the highest variable cost (₦ 25,126.50). This is in line with findings of Rukwe *et al.* (2020) in their study on Economics of Sesame Production among Small scale farmers in Southern Part of Taraba State, Nigeria, where labour constituted the highest variable cost of ₦35,000.00/ha. Therefore, sesame production is labour intensive in the study area. The average quantity of inorganic fertilizer used by the farmers was 61.3kg per hectare which is less than the recommended rate of 100kg per hectare. The low rate of fertilizer usage could be attributed to lack of fund. The average quantity of seed planted per hectare was 5.39kg. The seeding rate is higher than the recommended seedling rate of 5kg/ha (NAERLS, 2010). This means that the farmers are overusing seeds.

Seed are important factor influencing yield potentials in terms of optimum return of the crop in the study area. Herbicide had average cost of ₦ 17, 955/ha. This may be attributed to the market price is higher, and it is not often combined with manual weeding in the study area. The average quantity of herbicide used by sesame farmers was 9.45 litres per hectare which is not consistent with the recommended rate of 2-2.5 litres per hectare. The average cost of pesticides / insecticides used by sesame farmers for control of pests during flowering was ₦ 7,920.00/ha. Transportation costs of the output to house and markets was ₦ 1,200 and cost of bags was ₦ 1,964.2. The average fixed cost was estimated to be ₦ 16,450 per hectare. The total cost of cultivating a hectare of sesame farm was ₦ 88, 872.37.

The average quantity of yield per hectare in the study area was 421.6 kg. The average yield obtained 421.6 kg/ha is lower than the average yield of 1000kg when grown under improved management practices as reported by Essien *et al.* (2020). Low yield experienced in the study area was because of pests' and disease infestation and used of local varieties. The unit price was ₦ 550/kg on the average. The unit price was at its lowest amount of ₦400 during harvesting period and rose steadily to its peak at ₦ 550 at planting season. Average gross farm income of ₦ 231,880.00 per hectare was estimated. The net farm income of ₦143, 007.63 per hectare was estimated. The profitability index (ratio of total revenue to total cost minus 1) was 1.6, implying that for every ₦1 invested in Sesame farming there was a return of 60 Kobo. This finding implies that sesame production is highly profitable in the study area and thus any effort at expanding its production would be a good decision because a significant difference was observed in terms of cost of inputs incurred and returns realized. This is in line with the findings of Rukwe *et al.* (2021) who found profitability index 2.3 indicating that for each Naira invested, there is a return of 1.30 kobo.

The gross ratio which measures the overall financial success of a farm was 0.4. This ratio shows that the total farm costs was about 40% of the gross income. The lower the ratio, the higher the return per Naira invested. This indicates that sesame enterprise in the study area can survive in the long run.

Table 1: Costs and returns of sesame production in the area

Variables	Average quantity/ha	Unit price (₦)	Value (₦)
1. Gross Returns			
a) Average yield (kg)	421.6	550	231,880
2. Inputs			
i. Variable costs			
a) Seeds (kg)	5.39	620.00	3,341.8
b) Fertilizer (kg)	61.3	10,780.67	14,014.87
c) Herbicides (ltr)	9.45	1,900	17,955
d) pesticides (ltr)	3.60	2,200.00	7,920
e) Labour (man/day)	23.93	1,050	25,126.5
f) Transportation (₦)		300	2,100
g) Bags (₦)	7	280.6	1,964.2
Total Variable Cost			**72,422.37**
ii. Fixed inputs			
a) Cutlass			2,000
b) Hoe			1,600
c) Sprayer			12,500
d) Sickle			350
Total Fixed Cost			16,450
3. Total Costs (i)+(ii)			**88,872.37**
4. Net Farm Income NFI			**143,007.63**
5. Rate of Return			**1.6**
6. Gross Ratio (TC/GR)			**0.4**

Source: Field survey, 2022

Effect of socioeconomic variables on the output of sesame farmers

The regression model analyzed of the factors that affect the output of sesame revealed that age, household size, farm size significantly affected the output. The p-value was highly significant at 1% level ($p = 0.000$). From the regression results in table 2, the regression model explains about 73% of all the variability in the data set ($R^2 = 0.73$). This means that independent variables introduced in the model greatly explain the dependent variable. Age had a positive and significant ($p < 0.10$) effect on the output (net farm income) of sesame farmers in the study area. The older the farmer, the more experienced he/she is in the production of sesame in the study area. These farmers are willing to adopt new technologies that can enhance the productivity of the farm. The household size of the respondents had positive significant ($p < 0.05$) influence on the sesame farmers' net farm income due to the labor intensiveness of production. Hence, a large household size could provide a larger labour force for production. Findings revealed that farm size also have strong and significant effect (at 1% probability level) on the net farm income of the producer. In the study area, access to land is becoming more and more difficult. Most farmers rent the land they use for cultivation. Other variables like experience, age and educational level insignificantly influenced the net farm income.

Table 2: Effect of socio-economic variables on the output of sesame production

Variables	Coef.	Std.err	T	P>(t)
Constant	2.9643	0.68034	4.36***	0.000
Age	0.2612	0.13644	1.91*	0.058
Year of experience	-0.009	0.02767	-0.33ns	0.743
Sex	-0.013	0.10916	-0.12 ns	0.906
Household size	0.0181	0.00857	2.11**	0.037
Educational Level	0.0138	0.03077	0.45 ns	0.654
Farm size	0.6995	0.05354	13.07***	0.000
R-squared	0.7266			
Adj. R-squared	0.7069			
Prob.>F	0.000			

Source: Field survey, 2022

Constraints associated with sesame production

Table 3 shows the constraints faced by farmers in the study area. The result revealed that high cost of farm input is the commonest constraints affecting sesame production, as reported by 71.6% of the sampled farmers. Inadequate access to credit was second among the problems faced by farmers in the study area, as 65% of the sesame farmers considered it to be a problem, thereby indicating that inadequate access to credit was limiting sesame production. Farmers still have the chance to improve on production of sesame in the study area if they have access to credit facilities. About 61.7% of the sesame farmers agreed that inadequate extension services were one of the constraints in sesame production. This implies poor adoption to innovation and techniques that could have been used to promote sesame production, hence limiting the production potential of the crop. The findings also revealed that 60% of the farmers are confronted with the problem of Pest and disease. Farmers can cope with pests and diseases by sowing disease resistant varieties and the use of agrochemicals recommended for applications. The results further revealed that incessant farmer/herder clashes account for 48.3% of the constraint militating against sesame production. This implies where there is no peace, production activities will be affected, hence limiting the production potential of the crop. Inadequate market information ranked 6th constituting 45% of the sesame farmers that it is a constraint militating against sesame production. This implies that most farmers are unable to maximize their profit from sesame production due to poor market information. This result agrees with the findings of Essien *et al.* (2020) and Tahir *et al.,* (2021) that identified high cost of inputs, poor access to credit, poor extension and pest and disease to be major constraint faced by sesame farmers in Nasarawa and Adamawa States respectively.

Table 3: Constraints to sesame production in the study area

Constraint	Frequency (n=60)	Percentage
High cost of farm input	43	71.6*
Inadequate access to credit	39	65*
Inadequate extension	37	61.7*
Pest and disease	32	60*
Incessant farmer/herder clashes	29	48.3*
Inadequate market information	27	45*

Source: Field survey, 2022 *Multiple response

CONCLUSION AND RECOMMENDATIONS

Conclusion

Sesame production is a profitable venture in the study area. The regression model results revealed that age, household size, farm size significantly affected the output of sesame in the study area. Noticeable gaps in sesame production could be drastically improved upon if perceived constraints such as high cost of input, poor access to credit, pest and disease and inadequate extension services are addressed would increase the output of yield hence raise the disposable income of the farmer and earn the country more foreign exchange.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations were made:

i. Sesame farmers are therefore encouraged to form a cooperative group so that it can enable them to have access to loan by such doing they can assess credit to improve in their productivity.

ii. The farmers should be encouraged to use improved seeds to increases their farm output.
iii. The government and private sectors should encourage sesame farmers by improving extension services to acquire more innovations.
iv. Government and NGOs should subsidize farm input for sesame farmers to encourage them cultivate more since the venture was found to be a profitable venture in the study area.

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TRANSFER OF ROOT CROP TECHNOLOGY FOR ALLEVIATION OF POVERTY: THE CONTRIBUTION OF NATIONAL ROOT CROPS RESEARCH INSTITUTE, UMUDIKE, ABIA STATE

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ABSTRACT
The transfer of root crop technology plays a pivotal role in poverty alleviation and food security, particularly in regions where root crops are dietary staples. The contributions of the National Root Crops Research Institute (NRCRI) in Umudike, Abia State, Nigeria, to the dissemination of innovative root crop technologies and agricultural knowledge through a multifaceted approach involving research, development, and technology transfer, NRCRI has made significant strides in empowering smallholder farmers and communities. NRCRI's efforts in developing improved root crop varieties, managing pests and diseases, promoting value addition, and capacity building. NRCRI's methods, including Farmer Field Schools, demonstration plots, and extension services, have facilitated the adoption of sustainable agricultural practices, leading to increased agricultural productivity and improved livelihoods. The institute's contributions underscore the critical role of technology transfer in addressing poverty and food security challenges and offer valuable insights for similar initiatives worldwide.

INTRODUCTION
Root crops, including potatoes, sweet potatoes, cassava, yams, carrots, and beets, represent a diverse and vital group of agricultural commodities cultivated for their underground edible parts, such as roots, tubers, and rhizomes. These crops hold immense significance in global agriculture, addressing critical issues related to food security, income generation, and agricultural resilience. Root crops are fundamental to food security, particularly in regions where they serve as dietary staples. For example, cassava, a drought-tolerant root crop, plays a pivotal role in providing a consistent source of calories for over 800 million people in sub-Saharan Africa (FAO, 2013). Likewise, sweet potatoes, rich in complex carbohydrates and beta-carotene, contribute significantly to nutrition and food security in many developing countries (Low *et al.*, 2017).
Beyond their nutritional value, root crops serve as sources of income for millions of small-scale farmers. The sale of root crops, whether in local markets or for export, offers economic opportunities to rural communities. This income generation supports livelihoods and contributes to poverty reduction (Nweke *et al.*, 2002). Root crops also exhibit resilience to various environmental stressors, making them valuable assets in the face of climate change. Potatoes, for instance, can be grown at different altitudes and are adaptable to a range of climatic conditions, allowing farmers to diversify their income sources (Hijmans *et al.*, 2009). This resilience contributes to the sustainability of agriculture and helps mitigate the risks associated with changing weather patterns.

The Role of Technology in Poverty Alleviation
Technology plays a pivotal role in poverty alleviation by offering innovative solutions to longstanding challenges faced by impoverished communities. It provides pathways to economic empowerment, improved healthcare, education, and access to essential services. Technology can be instrumental in addressing poverty by fostering economic growth and enhancing the overall quality of life for marginalized populations.
One of the key ways technology contributes to poverty alleviation is through economic empowerment. Digital platforms and mobile banking systems, for example, enable individuals in remote and underserved areas to access financial services, save money, and engage in small-scale entrepreneurship (Jack & Suri, 2014). Moreover, the rise of e-commerce and online marketplaces creates opportunities for micro-entrepreneurs to reach broader customer bases, generating income and reducing poverty (World Bank, 2019).

In the context of healthcare, technology facilitates better access to medical services and health information, particularly in rural or underserved regions. Telemedicine, wearable health devices, and mobile health apps enable remote diagnosis and monitoring, improving healthcare outcomes for vulnerable populations (Free *et al.*, 2013). Educational technology also plays a critical role in poverty reduction by expanding access to quality education. Online learning platforms, Massive Open Online Courses (MOOCs), and digital libraries enable individuals to acquire new skills and knowledge, enhancing employability and income potential (Chuang & Chen, 2018).

Furthermore, technology-driven solutions can enhance agriculture, another critical sector in poverty alleviation. Tools such as precision agriculture, weather forecasting apps, and crop monitoring systems empower smallholder farmers to increase crop yields and income (FAO, 2019).

Role of NRCRI in Developing Root Crop Technologies

The National Root Crops Research Institute (NRCRI) in Umudike, Abia State, Nigeria, plays a pivotal role in the development of root crop technologies, contributing significantly to agricultural innovation and food security in Nigeria and beyond. NRCRI serves as a research hub, focusing on the improvement of root crops such as cassava, yams, and sweet potatoes. Its contributions span several key areas:

1. **Variety Development:** NRCRI conducts extensive research and breeding programs to develop improved varieties of root crops. These efforts aim to enhance crop yields, disease resistance, nutritional content, and other desirable traits. For instance, NRCRI has developed high-yielding cassava varieties that are resistant to pests and diseases, increasing the productivity of smallholder farmers (Akpan *et al.,* 2017).
2. **Pest and Disease Management:** The institute conducts research on the management of pests and diseases that affect root crops, providing farmers with innovative solutions to protect their crops. This research is crucial in ensuring stable root crop production, especially in regions where these crops are dietary staples (Nweke *et al.,* 2002).
3. **Technology Transfer:** NRCRI actively engages in technology transfer by disseminating improved varieties, best agricultural practices, and post-harvest handling techniques to farmers and extension services. Through workshops, training programs, and extension services, NRCRI ensures that farmers can effectively adopt and apply the developed technologies in their fields (Low *et al.,* 2017).
4. **Value Addition:** NRCRI also focuses on adding value to root crops by promoting their utilization in processed products. This not only creates income-generating opportunities for farmers but also reduces post-harvest losses. For example, NRCRI has been instrumental in promoting the processing of cassava into various products, including flour and chips (Banjo *et al.,* 2017).

Contribution of NRCRI in Alleviating Poverty

The National Root Crops Research Institute (NRCRI) in Umudike, Abia State, Nigeria, has made substantial contributions to poverty alleviation through its research, development, and technology transfer efforts related to root crops. These contributions are multifaceted and have had a profound impact on the livelihoods of smallholder farmers and communities:

1. **Improved Varieties:** NRCRI’s research programs have led to the development of improved root crop varieties with characteristics such as higher yields, disease resistance, and enhanced nutritional content. These varieties, when adopted by farmers, not only increase food production but also provide opportunities for surplus production and income generation (Akpan *et al.*, 2017).
2. **Pest and Disease Management:** NRCRI’s research on pest and disease management strategies has equipped farmers with knowledge and tools to protect their root crop yields. By reducing crop losses due to pests and diseases, farmers can secure their food supply and generate surplus for sale (Nweke *et al.*, 2002).
3. **Value Addition and Agribusiness:** NRCRI has played a pivotal role in promoting value addition to root crops. The processing of root crops into products like flour, chips, and snacks has created income-generating opportunities along the value chain, benefiting both farmers and entrepreneurs (Banjo *et al.*, 2017).
4. **Technology Transfer:** Through farmer field schools, demonstration plots, workshops, and extension services, NRCRI has actively transferred agricultural technologies and best practices to farmers. This knowledge transfer empowers farmers to make informed decisions, improve their agricultural practices, and increase their income (Low *et al.,* 2017).
5. **Climate Resilience:** NRCRI’s research on drought-resistant and climate-smart root crop varieties enhances farmers’ resilience to climate change. By providing options that thrive under challenging conditions, NRCRI helps protect farmers’ incomes and food security in the face of environmental uncertainties (Lipper *et al.,* 2014).
6. **Capacity Building:** The institute’s efforts to build the capacity of local farmers and extension workers contribute to improved agricultural productivity. Farmers equipped with knowledge and skills are better prepared to manage their resources effectively and lift themselves out of poverty (Van den Berg *et al.,* 2013).

CONCLUSION

In conclusion, root crops hold immense significance in addressing global challenges related to food security and poverty alleviation. These crops, including cassava, yams, and sweet potatoes, serve as dietary staples, provide resilience to challenging environmental conditions, and offer nutritional diversity, making them crucial for ensuring a stable food supply. Moreover, root crops contribute significantly to income generation, especially for smallholder farmers in impoverished regions, by offering economic opportunities along the agricultural value chain.

Technology transfer plays a vital role in harnessing the potential of root crops for poverty alleviation. Organizations like the National Root Crops Research Institute (NRCRI) in Umudike, Abia State, Nigeria, actively engage in research, development, and technology transfer efforts related to root crops. These institutions develop improved crop varieties, disseminate knowledge and best practices, and promote value addition, ultimately empowering farmers and communities to improve their livelihoods.

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STRATEGIES FOR ENHANCING THE AVAILABILITY OF ROOT CROPS PLANTING MATERIAL TO SMALLHOLDER FARMERS IN IKWUANO LOCAL GOVERNMENT AREA, ABIA STATE

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ABSTRACT

The paper provides a concise overview of the strategies designed to address the critical issue of enhancing the availability of root crops planting materials for smallholder farmers in Ikwuano Local Government Area, Abia State. Farmers in Ikwuano LGA face several challenges related to limited access, high costs, and inadequate knowledge among farmers regarding planting materials. To tackle these issues and promote sustainable agriculture, a multifaceted approach is proposed. The strategies outlined encompass the establishment of community seed banks, promotion of local seed production, and strengthening of farmer cooperatives. These initiatives aim to ensure a consistent supply of quality planting materials while reducing financial burdens on smallholder farmers. Additionally, the plan emphasizes the importance of educational programs and awareness campaigns to empower farmers with knowledge about improved varieties and modern agricultural practices. Infrastructure development and access to credit are critical components of the plan, addressing issues related to transportation, storage, and financial support. The collaborative efforts of government agencies, non-governmental organizations, research institutions, and community leaders are instrumental in the successful execution of these strategies. By implementing these comprehensive strategies, we aim to improve food security, enhance rural livelihoods, and promote sustainable root crop cultivation in Ikwuano Local Government Area, ultimately contributing to the broader goals of agricultural development and economic empowerment.

INTRODUCTION

Root crops play a crucial role in local agriculture, particularly in areas like Ikwuano Local Government Area, Abia State. Root crops encompass a diverse range of plants, including cassava, yam, sweet potatoes, and taro, among others, which thrive in various climates and soil conditions. The importance of root crops in local agriculture can be underscored by their contributions to food security, income generation, and overall agricultural sustainability.

Firstly, root crops are vital for ensuring food security in many areas. They are often staple foods that form the basis of daily diets for millions of people. For example, in sub-Saharan Africa, cassava and yam are primary sources of carbohydrates, providing a significant portion of the daily caloric intake for millions of individuals (Egesi *et al.*, 2012; Howeler, 2002). The reliable production of root crops is essential for addressing hunger and malnutrition, particularly in rural areas where access to diverse food sources may be limited.

Moreover, root crops serve as a source of income for smallholder farmers in local agriculture. They are relatively low-cost crops to cultivate and are well-suited to small-scale farming operations. Farmers can generate income by selling surplus root crops in local markets or processing them into value-added products like flour, starch, or snacks. This economic aspect is vital for rural livelihoods, poverty reduction, and the empowerment of smallholder farmers (Alamu *et al.*, 2019). Furthermore, root crops contribute to agricultural sustainability. They are often resilient to adverse weather conditions, such as droughts, making them suitable for cultivation in areas with variable climates (FAO, 2008). Additionally, they can be intercropped with other crops, promoting biodiversity and reducing the risk of pest and disease outbreaks (Ngailo *et al.*, 2013). The incorporation of root crops into local agricultural systems can enhance overall resilience and reduce the environmental impact of farming practices.

Significance of enhancing planting material availability for smallholder farmers

Enhancing the availability of planting materials is of paramount significance for smallholder farmers. Smallholder farmers, who typically cultivate small plots of land with limited resources, constitute a substantial portion of the world's agricultural workforce, particularly in developing countries (Hazell & Wood, 2008). Ensuring access to high-quality planting materials holds several crucial implications for their livelihoods and agricultural productivity.

First and foremost, improved access to planting materials directly impacts food security. Smallholder farmers often rely on their own seed stocks, which may be of variable quality and susceptible to diseases or pests. By providing them with access to certify and disease-free planting materials, the risk of crop failure due to poor-quality seeds is reduced, thereby enhancing food production and availability (FAO, 2010). This is particularly important in areas where smallholder farmers play a critical role in supplying food to local communities.

Secondly, enhancing planting material availability contributes to increased agricultural productivity and income for smallholders. High-quality planting materials are typically associated with higher crop yields, as they are often bred for traits like disease resistance, improved yield potential, and adaptability to local conditions (Almekinders *et al.*, 2018). Increased productivity not only ensures an adequate food supply but also allows farmers to generate surplus produce for sale in local markets, thereby boosting their income and economic well-being.

Furthermore, the availability of quality planting materials is essential for crop diversification and resilience. Smallholder farmers are vulnerable to climate change and market fluctuations, and having access to a variety of planting materials allows them to adapt to changing conditions (Lipper *et al.*, 2014). Diversification can also reduce the risk of crop failures and enhance the sustainability of farming systems.

Current Challenges in Availability of Root Crops Planting Material

The availability of root crops planting materials faces several significant challenges, particularly in areas like Ikwuano Local Government Area, Abia State. These challenges can hamper agricultural productivity and food security, and they demand attention to ensure the sustainability of root crop cultivation by smallholder farmers.

One major challenge is the limited access to quality planting materials. Smallholder farmers often rely on saved seeds or cuttings from previous harvests, which may carry diseases, have low genetic diversity, or suffer from degeneration over time (Alamu *et al.*, 2019; Grubben & Denton, 2004). Ensuring a consistent supply of disease-free, high-yielding planting materials is critical to overcoming this limitation.

Another challenge is the high cost associated with acquiring planting materials. Improved and certified varieties are often more expensive, making them less accessible to resource-constrained smallholder farmers (Ezeh *et al.*, 2018). This cost barrier can discourage farmers from adopting improved varieties and hinder the adoption of modern agricultural practices.

Inadequate knowledge and awareness among smallholder farmers regarding the importance of using quality planting materials and the availability of improved varieties represent another significant challenge (Hossain *et al.*, 2019). Without proper training and extension services, farmers may continue to use traditional materials, limiting their agricultural potential and yield.

Strategies for Enhancing Availability of Root Crops Planting Material

Enhancing the availability of root crops planting materials is crucial for improving agricultural productivity and food security, especially for smallholder farmers in areas like Ikwuano Local Government Area, Abia State. Several strategies can be employed to address the current challenges and boost the accessibility of quality planting materials.

One effective strategy is to promote local seed production (Almekinders *et al.* 2018). This involves establishing community seed banks, providing training on seed production techniques, and supporting farmers in seed multiplication. By decentralizing seed production and empowering local communities, this strategy ensures a consistent supply of planting materials that are well-adapted to local conditions.

- Strengthening farmer cooperatives and associations is another key strategy (Harris *et al.*, 2017). These organizations can facilitate collective procurement of planting materials, enabling bulk purchases that reduce costs for individual farmers. Capacity building for cooperative leaders and members can also enhance their ability to negotiate favorable terms with seed suppliers.
- Research and extension services play a vital role in improving planting material availability. Collaborating with agricultural research institutions can lead to the development of improved root crop varieties (Ezeh *et al.*, 2018). Additionally, conducting trials for these varieties and disseminating the findings through extension programs helps educate farmers on best practices for selecting and using quality planting materials.

- Access to credit and financial support is essential to address the high cost of planting materials (FAO, 2010). Establishing microcredit schemes for farmers and subsidizing the cost of planting materials can alleviate the financial burden on smallholders. Linking farmers with financial institutions enables them to access loans and resources for investing in quality planting materials.
- Information and awareness campaigns are pivotal in increasing knowledge among smallholder farmers (Hossain *et al.*, 2019). Creating educational materials, organizing workshops, and utilizing local media can help disseminate information about the benefits of root crops and improved planting materials. Raising awareness empowers farmers to make informed choices about their agricultural practices.
- Finally, infrastructure development is essential for the distribution and preservation of planting materials (FAO, 2010). Improving transportation networks ensures that planting materials can reach remote areas, while building storage facilities helps prolong the shelf life of seeds and cuttings. Access to clean water for irrigation is also critical to support root crop cultivation.

Implementing these strategies for enhancing the availability of root crops planting materials is essential to boost agricultural productivity and food security for smallholder farmers in Ikwuano Local Government Area, Abia State. By addressing the current challenges and promoting sustainable practices, these strategies can contribute to improved livelihoods and agricultural sustainability.

Challenges and Mitigation

Addressing the challenges faced in enhancing the availability of root crops planting materials for smallholder farmers in areas like Ikwuano Local Government Area, Abia State, requires careful consideration of potential obstacles and the development of effective mitigation strategies.

1. **Limited Access to Quality Planting Materials:** To mitigate this challenge, it is crucial to establish and maintain community seed banks, ensuring a consistent supply of high-quality planting materials. Additionally, partnerships with agricultural research institutions can facilitate the development of disease-resistant and high-yielding varieties, addressing the issue at its root (Almekinders *et al.,* 2018).
2. **High Cost of Planting Materials:** To alleviate the financial burden on smallholder farmers, subsidies can be introduced, making improved planting materials more affordable. Microcredit schemes can also be established to provide farmers with access to funding for purchasing quality planting materials (FAO, 2010).
3. **Inadequate Knowledge and Awareness:** Education and awareness campaigns should be intensified to inform farmers about the benefits of using quality planting materials. Extension services play a crucial role in training farmers on best practices and disseminating information about improved varieties (Hossain *et al.,* 2019).
4. **Infrastructure Limitations:** To overcome infrastructure challenges like poor transportation networks or lack of storage facilities, partnerships with government agencies and NGOs can be established to fund and implement infrastructure development projects. This includes improving road networks for easier transportation of planting materials and constructing storage facilities to prolong seed shelf life (FAO, 2010).
5. **Climate Change and Environmental Factors:** Climate-smart agricultural practices, such as diversifying crops and implementing sustainable farming techniques, can help mitigate the effects of climate change on planting material availability (Lipper *et al.*, 2014). Research into climate-resilient crop varieties can also be prioritized.

In summary, addressing the challenges related to the availability of root crops planting materials requires a multifaceted approach that combines policy changes, financial support, education, and infrastructure development. Mitigation strategies should be tailored to the specific needs and constraints of the local context to ensure the sustainability of root crop cultivation and improve the livelihoods of smallholder farmers.

CONCLUSION

In conclusion, the challenges surrounding the availability of root crops planting materials in areas like Ikwuano Local Government Area, Abia State, present significant barriers to agricultural productivity and food security. However, by implementing a well-structured plan that encompasses strategies such as promoting local seed production, strengthening farmer cooperatives, enhancing knowledge and awareness, and investing in infrastructure, there is great potential for improvement. These strategies not only address the immediate challenges but also pave the way for a more sustainable and resilient agricultural sector. Through collaboration among stakeholders and a commitment to mitigating challenges, we can empower smallholder farmers, enhance food security, and contribute to the economic development of rural communities. The importance of root crops in local agriculture cannot be overstated, and by focusing on availability, we can make meaningful strides towards improving the livelihoods and well-being of those who rely on them.

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LEVEL OF ADOPTION OF ORANGE FLESHED SWEET POTATO AMONG FARMERS IN EBONYI STATE, SOUTHEASTERN NIGERIA

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ABSTRACT
The study was carried out to determine the level of adoption of orange-fleshed sweet potato (OFSP) varieties among farmers in Ebonyi State, Southeastern Nigeria. A multistage sampling technique was used to select 128 OFSP farmers from two agricultural zones in the state. Data were obtained using well-structured questionnaire and analyzed using descriptive statistics, such as means, percentages, tables and frequency distribution tables and adoption score index of 7 point Likert scale. Result indicated that the mean age of sweet potato farmers in Ebonyi State was 49.86 years, mean farm size was 1.71ha and mean years of farming experience was 9.65. The levels of adoption of OFSP by farmers were: UMUS-PO/I (X=3.78) and UMUS-PO/3 (X=3.63), showing a high level of OFSP adoption in the Study Area. The result further indicated that the major determinant of OFSP low adoption were; inadequate credit facilities (74.21%), poor government support (68.75%) and low extension coverage (66.41%). It was recommended that government should provide support through the provision of credit facilities and adequate extension personnel to the farmers in Ebonyi State.
***Keywords**: adoption, OFSP, farmers, determinant and Ebonyi*

INTRODUCTION
Orange fleshed sweet potato (OFSP) was developed to enhance food security status of farmers and improve their livelihood.The adoption of OFSP should be an important route to improve the livelihood of poor sweet potato farmers by enhancing sweet potato productivity, food security status, income level and poverty alleviate among the farmers and generality of Nigerians (Solomon *et al*, 2010; Solomon *et al*, 2011). Sweet potato is a very important food crop and ranked fourth in terms of consumption as the world's most important food crop. However, the orange fleshed sweet potato varieties are rich in beta carotene, (a precursor of Vitamin A.) a micronutrient that combat vitamin A deficiency [VAD] problem in sub-Saharan Africa (Solomon *et al*., 2011).
The adoption rate of OFSP is subject to its profitability, degree of risk associated with it, capital requirements, agricultural policies and socio-economic characteristics of farmers (Shideed and Mohammed, 2005; Solomon, 2010; Solomon et al., 2011). Vitamin A and Iron deficiencies have several negative health and economic consequences, including earlier mortality rate of pre-school age children and reduced productivity of adults. It has been observed that there has been a problem of low adoption of orange-fleshed sweet potato in Nigeria (Nwosu, 2005). The essence of this study was to find out the determinant of low adoption of OFS in the study area.

METHODOLOGY
The study was conducted in Ebonyi State, Nigeria. Multi-stage sampling techniques were adopted for the study. Two out of the three agricultural zones were purposively selected. The zones were Ikwo and Ezza South. These zones were selected because of farmers' involvement in Orange- fleshed sweet potato production. The second stage involved a random selection of two blocks from the chosen agricultural zones making it four [4] blocks. The third stage involved random selection of two circles from each of the chosen blocks to give a total of eight [8] circles. Finally, sixteen OFSP farmers were randomly selected from each of the eight [8] circles given a total of one hundred and twenty- eight [128] respondents selected for the study.

Adoption score index
The level of adoption of OFSP was determined using adoption score index. This was achieved with the aid of a Likert scale graded thus: Unaware = 0, Aware = 1, Interest = 2, Evaluation = 3, Trial = 4, Acceptance = 5 and Satisfaction = 6. In accordance with Okoye *et al* (2009). The mean adoption level was determined as follows:
Mean score was computed by multiplying the frequency of each response pattern with its appropriate nominal value and dividing the same with the number of respondents to the terms.

This is summarized with the equation below:
Decision Rule
Less than 1.0 = Unaware stage of OFSP
1.0 - 1.49 = Awareness stage of OFSP
1.5 - 1.99 = Interest stage of OFSP
2.0 - 2.49 = Evaluation stage of OFSP
2.5 - 2.99 = Trial stage of OFSP
3.0 - 3.49 = Adoption stage of OFSP
3.5 above = Satisfaction stage of OFSP

RESULTS AND DISCUSSIONS

Table 1: shows that 92.19% of sweet potato farmers in Ebonyi State had one form of formal education or the other as against 7.81 that had no formal education. The results indicated that the respondents in the study area had more literate farmers. The high proportion of the literate people among the OFSP farmers implied that they are in a better position to be aware, understand and adopt the crop. Education has always been known to play a positive role in the adoption of innovation among farmers. Also, 50.78% of OFSP farmers had household sizes of between 4 and 6 persons; 41.41% of them had household size of between 7 and 9 persons and only 7.81% had a household size of between 1 and 3 persons. The mean household size was 6 persons. The results collaborated with the study of Ekwe and Onunka (2006) which indicated that most farmers in Ebonyi State had large households that readily provided labor for on and off- farm activities. The farm size result shows that the majority [59.38%] of the OFSP farmers had farm sizes of between 1 and 2 hectares. This finding is in agreement with the work of Emodi (2009) who observed that small-scale farmers predominate in the Southeast agro-ecological zone of Nigeria. The result also showed that 68.75% of orange-fleshed sweet potato farmers had farming experience of between 1 and 9 years. In addition, 47.66% of orange- fleshed sweet potato farmers in Ebonyi State belong to cooperation societies. Group membership in a Cooperative Society enables farmers to access loans to purchase additional equipment (Shiferaw et al, 2006). The result also shows that only 42.97 % of orange- fleshed sweet potato farmers had access to Extension Agents. The results of the level of OFSP adoption by farmers are presented in Table 2.

Table 1: Selected Socio-economic Characteristics of Sweet Potato Farmers in Abia State

Variables	Frequencies	Percentages
Educational Status		
No of formal education	10	7.81
Primary education	45	35.16
Secondary education	43	33.59
Tertiary education	30	23.44
Household size		
1-3	10	7.81
4-6	65	50.78
7-9	53	41.41
Farm Size		
<90	22	17.19
1.0 -3.0	61	47.65
3.1 -5.0	27	27.09
5.1 and above	18	18.06
Farming Experience		
0-9	88	68.75
10-19	38	24.22
20 above	2	1.56
Membership of cooperative		
Yes	61	47.66
No	67	52.34
Access to extension agent		
Yes	64	50.0
No	64	50.0
Total	**128**	**100**

Source; Field Survey, 2021

Table 2: Distribution of OFSP Farmers According to their levels of Adoption

OFSP	Unaware	Aware	Interest	Evaluation	Trial	Accept	Reject	Total	Mean adoption score
UMUSPO/3	4	9	20	16	39	29	11	464	3.63
	(0)	(9)	(40)	(48)	(156)	(145)	(66)		
UMUSPO/1	1	5	19	15	49	34	5	484	3.68
	(0)	(5)	(38)	(45)	(196)	(170)	(30)		**3.71**

Source; Field Survey, 2021

The level of Adoption of Orange - fleshed sweet potato among farmers in Ebonyi State showed that farmers adopted UMUSPO/3 (X=3.63) and UMUSPO/1(X=3.78) and the level of Adoption was high. The grand mean adoption score for Orange- fleshed sweet potato varieties was (X=3.71). This finding is in agreement with Nwakor *(*2021) which reported a high level of women participation in Orange -Fleshed Sweet potato production among small- scale farmers in Abia State.

CONCLUSION

The study showed a high level of adoption of orange fleshed sweet-potato among farmers with formal education. Majority of the educated farmers who cultivate the orange fleshed sweet potato (UMUSPO/1 and UMUSPO/3) know of its health benefits. OFSP boost immunity, it is good for pregnant women and lactating mothers. Orange fleshed sweet potato is good Vitamin A micro-nutrient food for pre-school age children. The study also indicated that most farmers in Ebonyi State had large household sizes that readily provided labour for on and off-farm activities. OFSP farmers needed strategic support to boost OFSP adoption and productivity across the country.

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FOOD INSECURITY IN NIGERIA: CASSAVA AS A RESCUE CROP

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ABSTRACT

Cassava has replaced a number of traditional staples since its introduction to Africa in the sixteenth centuries. It has been successfully integrated into many agricultural and food systems across the continent. Today, cassava can be produced primarily for food purposes, particularly in the forms of gari or fufu particularly for small-scale farming families. It has traditionally been a crop that provides food security in Nigeria, due to its characteristics and its ability to thrive in even the most difficult conditions. Nigeria has been identified as a country with a high rate of food insecurity and vulnerable to climate change effect with history of environmental catastrophes that have had a significant impact on people's lives. By increasing cassava production, food security will be improved, as the longer the cassava remains in the farm, the more likely these groups of people are to have access to food.
Keywords: *Cassava, food security, farmers, small scale, production.*

INTRODUCTION

The world production of cassava amounted to 302.66m tons in 2020 (Onyediako and Adiele, 2022) and Africa is the largest region of cassava growing with 193.62m tons in 2020. Nigeria is the largest producer in the world, with 60m tons with others countries like South-East Asian countries, Brazil, Indonesia, Thailand, and Vietnam following FAO (2022). The total area of cassava harvested in the world has increased significantly in recent years, with the total area harvested in 2020 being 7.7m ha, according to (FAOSTAT, 2022). Nigeria is the world's biggest cassava producer but more than 90% of cassava production is locally consumed being one of the Nigeria's most important staple foods. More than 90% of the country's rural families consume cassava daily, whether it is in the forms of gari, fufu, starch, tapioca, chips, or in the supported forms such as bread, chin-chin, doughnut, cake, and chips.

According to the Food and Agriculture Organization of the United Nations (FAO), cassava is Africa's third most important source of calories (after rice and maize) in Africa's tropics and subtropics (FAO, 2020). Cassava is widely cultivated in several sub-Saharan African countries. Currently, more than 50% of the global consumption of cassava is in Africa. Cassava has replaced a number of traditional staples since its introduction to Africa in the sixteenth and has been successfully integrated into many agricultural and food systems across the continent. Today, cassava can be produced primarily for food purposes, particularly in the forms of gari or fufu. The root and stem of cassava are gradually integrated into the agri-business sector (Ezeibe, 2015). Initially, cassava was used as a famine reserve crop, as it offered a more dependable food source during drought and famine periods. In recent years, it has become a staple food as well as a profitable cash crop with industrial importance in the global economy. Currently it is considered as a cash crop generating huge cash income for most households, compared to other staples, which has a positive impact on poverty alleviation (Obisesan, 2012; Ezeibe, 2015). Cassava is considered a crop for food security in many underdeveloped countries, as it can be a source of calories even during the dry season. Originating in South America's tropical rain forests, cassava has become a staple crop in many African countries. In recent years, many countries have begun to explore new methods in their agricultural systems to sustainably increase production to support food security and to produce non-food items from cassava.

According to the International Fund for Agriculture in Development (IFAD) (2012) that Africa, is home to 600 million people who rely on cassava for dietary food energy. Nigeria continues to be the largest producer of cassava in the world, and for the entire population living in lowland and subtropical areas of West and Central Africa, it is a major source of dietary energy. However, Nigeria has not been able to produce enough cassava to export due to the small size of many cassava farms and several factors that lead to low productivity on most of the farms in Nigeria, such as manual labor, the use of little or no agro-chemicals, the lack of experience in using high-yield roots, the lack of resistant varieties to major disease and pest, and other environmental issues, the worst of which are climate changes and insecurity.

According to the International Monetary Fund (IMF) (2022), food security is the availability of sufficient food to meet the calorie requirements of an adult female at a daily caloric rate of 2200 to 3200 calories per day and an adult male at a caloric rate of 2900 to 3000 calories per day. Furthermore, the report further stated that the cost associated with meeting the caloric rate of 2251 per day (agricultural weight requirement for food security) is approximately ₦ 82,000.00 per capita per year. As a result, approximately 40% of the population in Nigeria is classified as food insecure, as supported by the research of Mekonnen *et al*. (2021) and Okou *et al*. (2022). The prices of staple foods in sub-Saharan Africa have increased by an average 23.9% in the period of 2020-22. This has made it difficult for those with an average income to access food.

Otaha (2013) defined food insecurity as a situation in which individuals are not adequately nourished due to a lack of physical access to food, as well as a lack of economic or social support. Those who experience food insecurity include those whose food intake is lower than their minimum energy requirements, as well as individuals who experience physical symptoms due to nutritional deficiencies or an inadequate diet, or due to the body's inability to utilize food effectively due to an infection or disease while FAO/CFS (2010) defined food insecurity as the consequences of inadequate intake of nutritious food, taking into account the physiological utilization of food as part of nutrition and health.

Nigeria has been identified as a country with a high rate of food insecurity, a vulnerability to climate change, and a history of environmental catastrophes that have had a significant impact on people's lives. Despite its declining economy, the country still has an estimated 96 million people living in extreme poverty, representing 48% of the population. As the population continues to expand and poverty rates remain relatively stable, this has resulted in an increase in absolute poverty, which in turn leads to an increase in food insecurity. This paper examines the role and potential of cassava as a rescue crop in Nigeria's efforts to reduce food insecurity. The novel varieties of cassava developed by NRCRI Umudike in partnership with IITA Ibadan, with the assistance of local and foreign donor agencies, possess the characteristics of high yield, resistance to disease, early maturing, and high food quality, which will enable Nigeria to capitalize on the opportunities presented by their availability.

Roles and potentials of Cassava to rescue food insecure people in Nigeria

Certain varieties of cassava are resistant to drought and can be cultivated on inhospitable soils, with the ability to remain in the soil for a period of two years. This makes cassava a major source of food security, particularly for small-scale farming families. These families are essentially subsistence farmers who use cassava as a food source. They harvest pieces of food when there is a food shortage in the home or when they need to provide for family members, including children, siblings, and husbands and wives, who may be out of the home or in urban areas. By increasing cassava production, food security will be improved, as the longer the cassava remains in the farm, the more likely these groups of people are to have access to food.

The long value chain of cassava has enabled it to be locally processed into a variety of food products, providing an alternative source of sustenance, particularly for poor households. In Nigeria, cassava is a dietary staple food, with products such as cassava flakes (Gari), flour (Pupuru and Lafun), paste (akpu and Fufu), and sliced roots (abacha) all derived from the storage roots. According to Montagnac *et al*. (2009), in cases of food shortage, many people turn to Elibo, a combination of cassava and maize flour. To maximize the potential of the cassava sector in areas such as export, industrial use, food security, and economic development, it is essential to harness the latest technologies and innovations in production, processing, and packaging.

Leaves of cassava varieties that are low or free from cyanide are used as vegetable in the diets of many rural populations in Nigeria. Cassava leave has been identified as a source of vitamins and proteins. Also cassava leave can easily be converted to protein by small ruminant animals reared by the resource poor farmers in Nigeria. It is a common practice that rural farmers use cassava leaves to feed their livestock which in turn are used to boost food security in the area. Also cassava stem is currently commercialized in Nigeria, as a result of the robust cassava seed system that is transforming into a formal system from the hitherto informal system that has been in existence for a very long time in Nigeria. Cassava stem can generate up to ₦400,000 per ha of land, thereby increasing income to farmers. Such increased incomes are potential food security platforms for the rural cassava farming populations in Nigeria.

CONCLUSION

Cassava has been a crop of interest in Nigeria because of the numerous advantages the crop can offer to farmers. Most Nigerians rely on cassava as their food bank especially at this time of severe economic hardship. Cassava farm owners are less vulnerable to food stress because they are sure of at least one meal per day. In this circumstance the pains of food insecurity and its attendant consequences are felt in a lesser proportion than those that do not own cassava farms. At this period, the technological advancement deployed by the research centre with mandate on cassava and her collaborators to ensure high yielding, early maturing and disease free varieties are made available to farmers should be exploited to increase food security in Nigeria.

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THE INFLUENCE OF FARMER DISPLACEMENT ON HOUSEHOLD FOOD SECURITY IN BENUE STATE, NIGERIA

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ABSTRACT
This study focuses on the impact of internal displacement on household food security among farmers in Benue State, Nigeria. It investigates the relationship between internal displacement and food security. The study employed a social survey design, using a combination of cluster, random, and purposive sampling to select 429 respondents. Data was collected through semi-structured questionnaires and analyzed quantitatively and qualitatively. The study found that internal displacement resulted in reduced food production (mean score 3.54), acute food shortages, and increased food prices (mean score 3.55), as well as decreased access to safe food (mean score 3.38). There was a strong positive relationship (R=0.802) between rural crop farmers' displacement and household food insecurity. Internal displacement has devastating effects, leading to significant changes in family structure, gender roles, relations, and identities.
Keywords: *Displacement; Food security; rural farmers; Impact.*

INTRODUCTION
Internal displacement is a common consequence of Nigerian inter-communal, religious and political violence, flooding and forced evictions (Internal Displacement Monitoring Center -IDMC, 2013). In other words, internal displacement of persons could be triggered by natural disasters or human-induced conflict which leads to violent clashes. Irrespective of the cause of the displacement, the phenomenon always leaves negative socioeconomic footprints on millions of people worldwide. A serious source of concern however lies with internal displacement of persons arising from human-induced violent clashes and conflicts in recent times. Internally displaced persons (IDPs) arising from violent clashes are victims of various kind of injustices or violence confrontations, perpetrated against them by their own government or agents of communal clashes, riots, terrorism, natural disasters, religious conflicts, among others (Hamzat, 2013). In recent times, the issue of herders' invasion and occupation of farm land across the regions in Nigeria has become a major threat to food security (Olobakole &omowumi 2017). Displacement around the world has been a main cause of a rise in global hunger in recent years. More recent figures as indicated by The UNHCR (2016) and World Bank (2017) show that the number of displaced persons rise from about 40 million people in 2011 to almost 66 million in 2016 (World Bank, 2017).
In Benue State, these clashes reinforce circles of extreme poverty and hunger, and destroy social status, food security and affect mostly the most marginalized groups that include women and children of a teaming population (FAO 2017). In the host communities, nomadic herdsmen relocate as a result of conflict and host farmers, especially women and children, who remain behind, stop going to the distant farms for fear of attack by the nomads in the bush. Such displaced farmers have become a source of liability to other farmers whom they have to beg for food for themselves and their families (Bukari, Sow, & Scheffran, 2018). This has created a vicious cycle of poverty in such communities and affected the education of children leading to obstacles in their development and mass displacement. These conflicts have demonstrated high potential to exacerbate insecurity and food crisis particularly in rural communities where most of the conflicts are localized, with reverberating consequences nationwide. The inversion and pre-occupation of farm lands in Nigeria by Fulani herders have persisted and stand out a threat to national food security, livestock production and eradication of poverty with farmers often regarded as the most vulnerable (Dimelu *et al*., 2017). The invasion of north-central states by herdsmen have forced farmers to abandon their fertile farmlands, rendering several communities deserted and reduced farmers to tenants in internally displaced persons (IDPs) camps (Dimelu, Salifu, Enwelu & Igbokwe,

2017). It is against this background that this study examined the impact of internal displacement on household food security among farmers in Benue State.

MATERIALS AND METHODS

This study employed social survey design. A combination of Cluster sampling, random sampling and purposive sampling was used in selecting the respondents for the study and data collected with the use of a well semi-structured questionnaire. Benue State is divided into three senatorial districts, namely, North East senatorial district (Zone A) North West Senatorial District (Zone B) and Benue South Senatorial district Zone (C). These three Senatorial Districts make up the three clusters selected for this study.

One (1) L.G.A was purposively selected from each of the three senatorial districts. These are L.G.As that has the greater number of displaced persons. Logo Local Government area was selected from Zone A. Makurdi Local Government Area was selected from zone B. Agatu local government area was selected from zone C. Furthermore, two (2) internally displaced persons (IDPs) camps and two (2) communities were randomly selected from Logo and Makurdi L.G.As while only two communities were randomly selected from Agatu L.G.A. This is because there is no IDP camp in zone C, as displaced persons are living within the host community.The total number of registered displaced households in the six (6) selected communities (11,353) and four (4) IDP Camps (4,886) is sixteen thousand, two hundred and thirty nine (16,239). This figure therefore represents the sample frame (Benue State Emergency Management Agency 2018) from where a total number to 429 respondents were drawn using a mathematical formula given by Miller and Brewer (2003). Data were analyzed using descriptive statistics such as percentages and mean and inferential statistics such as correlation.

RESULTS AND DISCUSSION

The results point out that that internal displacement lowered the sufficient production of food with a mean score of 3.54.(Table 1). It also identified acute food shortage and increase in food prices ($\bar{x}$=3.55) as one of the impacts of internal displacement in the area. There is lack of access to safe food ($\bar{x}$=3.38); drastic reduction of production of nutritious food ($\bar{x}$=3.47); shortage of labour ($\bar{x}$=3.47); hunger ($\bar{x}$=3.53); degraded nutritional status on IDPs ($\bar{x}$=3.58); food lost in the farm ($\bar{x}$=3.88); limited or no access to farm lands ($\bar{x}$=3.78); fear of uncertainties in cultivating new farm lands ($\bar{x}$=3.8); and Continuing internal displacement would finally result to total damage of national food staple ($\bar{x}$=4).

The above is an indication of food insecurity in the area due to outflow of large numbers of physically active and economically productive as well as educated and non-educated population from the affected areas due to violence and incessant attacks. It is a known fact that the problem of food insecurity is usually associated with rural households and the urban poor who are more vulnerable to high food prices and limited access to food as a result of low income by implication, internal displacements causes economic recessions, and employment disruption and erode finances for social protection, and thus cause food insecurity through these channels.

This results Shows lack of access to necessities of life such as food, water and shelter. The findings are in line with the assertions of IDMC (2019) that internal displacement impacts the lives of affected people in many ways: It can influence their health, education, livelihoods, housing conditions, social life, security and environment positively, but most often does so negatively. Some of these impacts can have further repercussions and create vulnerability loops that are difficult to get out of. For instance, when a family loses its income as a result of displacement, young family members may be forced to drop out of school to support their parents, sacrificing their chance to get a degree and eventually making it harder for them to find decent work.

The findings are indications that internal displacement affects food security in terms of degradation of Agro-ecosystem area, limited or lack of access to land. This agrees with the assertions of Terminiski (2013) that people might be evacuated from their habitual homeland without adequate compensation, guarantees or mechanisms of social support, or to the initial phase of a process of resettlement which is associated with physical relocation of people from their homes. Internal displacement of persons also provides fertile ground for human rights abuses including torture, rape, killings, as well as forced evictions, loss of food and loss of heritage. The finding support Ellen *et al.*, (*1999*),who stated that conflicts also tend to affect food and commodity prices; such prices influence the levels of farmers' income and their vulnerability to food insecurity. The findings imply that irrespective of the cause of the displacement, the phenomenon always leaves negative socioeconomic footprints on millions of people worldwide.

Table1: Impact of displacement on food security

Impacts	Strongly Agree	Agree	Disagree	Strongly Disagree	Mean
Availability					
Internal displacement lowers the sufficient production of food	250(69.4)	60(16.6)	45(12.5)	5(1.38)	3.54
Food lost in the farm	344 (95.5)	16(2.5)	-	-	3.88
Limited or no access to farm lands	311(86)	39(8.6)	10 (2.7)	-	3.78
Affordability					

Increase in food prices	210 (58.3)	140(38.9)	7(14)	3(1.94)	3.55
Access					
Internal displacement causes lack of access to safe food.	213(59.16)	98 (24.7)	32 (8.8)	17(4.7)	3.38
Continuing internal displacement would finally result to total damage of national food staple	360 (100)	-	-	-	4
Utilization					
As a result of internal displacement, production of nutritious food is drastically reduced	198(55)	142(39.4)	11(3.0)	9(2.5)	3.47
Hunger	230(63.8)	100(27.7)	20(5.5)	10(2.7)	3.53
Internal displacement has negative impact on nutritional status on IDPs	250(69.4)	80(22.2)	20(5.5)	10(2.7)	3.58
Shortage of labour	198(55)	142(39.4)	11(3.0)	9(2.5)	3.47
Fear of uncertainties in cultivating new farm lands	300(83.3)	60(16.7)	-	-	3.8
Poverty					

Field survey, 2021: Decision rule: ≥ 2.5 = accepted < 2.5 = rejected
Figures in parenthesis are percentages

Table 2: Relationship between Rural Crop Farmers Displacement and Household Food Insecurity in Benue State

Correlations

		Rural crop farmers displacement	Household food insecurity
	Pearson Correlation	1	.713
	Sig. (2-tailed)		.802
	N	360	360
	Pearson Correlation	.713	1
	Sig. (2-tailed)	.802	
	N	360	360

Source: Field data 2022

The result reveals that there is strong positive relationship (R=0.802) between rural crop farmers' displacement and household food insecurity. This implies that if displacement of farmers continues to increase, household food insecurity in the study area will also increase. Its malevolent effects on individuals, families, and communities are wide-ranging and include 'impoverishment, social isolation, exclusion from health, welfare and education provision, the breakdown of social relationships and support structures, and the undermining of authority structures and social roles.

CONCLUSION

The findings thus conclude that the impacts of internal displacement on IDPs are devastating. It leads the people to dramatic changes in family structure and gender roles, relations, and identities.

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A REVIEW OF FARMERS WILLINGNESS TO PAY FOR AGRICULTURAL EXTENSION SERVICES IN NIGERIA

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ABSTRACT:

Agricultural extension services have long been recognized as crucial to enhancing agricultural productivity and food security in Nigeria. This paper provides a comprehensive review of the willingness of Nigerian farmers to pay for these services, shedding light on historical developments, policy frameworks, and factors influencing farmers' decisions to invest in extension services. Historically, agricultural extension services in Nigeria have evolved from government-led initiatives to a more pluralistic approach involving private and international organizations. The transition has been marked by changing strategies and challenges, with efforts to improve the effectiveness of extension services. Through an examination of various studies, this review explores the factors influencing farmers' willingness to pay for extension services across different regions of Nigeria. Factors such as age, income, farm size, education, and experience in agriculture play significant roles in shaping farmers' decisions to invest in extension services. The findings reveal varying levels of willingness to pay among farmers, influenced by economic conditions, government policies, and the perceived benefits of extension services. The paper also discusses the policy landscape in Nigeria, highlighting the progression of agricultural extension policies over the years and their impact on the extension system. From the early Agricultural Development Projects (ADPs) to the more recent Agricultural Extension Transformation Agenda (AETA), these policies have aimed to redefine roles, responsibilities, and approaches in extension services. However, challenges in implementation, particularly at the state level, have posed obstacles to their success.

Keywords: *Agricultural Extension Services, Willingness, Pay, Nigeria, Review*

INTRODUCTION

The improvement of farm production and food security in Nigeria has historically been greatly aided by agricultural extension programs. These services, which included technology transfer, rural development, managerial skills, and non-formal education, were first designed as a way to bring research-based information and knowledge to rural sectors. According to the traditional African perspective of extension, the main goals were to train farmers, transfer technology, increase production, and improve yields (Christoplos, 2010). As a holistic system, extension seeks to open up access to knowledge, information, and technologies for farmers, their organizations, and other market participants. Additionally, it encourages cooperation with research, education, agriculture, and relevant institutions, allowing them to advance their management, organizational, and technological capabilities (Christoplos, 2010).
In the context of agricultural extension services, the idea of "willingness to pay" (WTP) is relevant. According to Birner et al. (2006), agricultural extension is a system made up of many organizations that helps people involved in agriculture solve problems and acquire knowledge, skills, and technology to improve their quality of life. Governmental bodies, producer groups, agricultural associations, and private sector actors are all involved in this. WTP is an indicator of farmers' willingness and readiness to invest in agricultural extension services. Farmers are willing to pay for these services when they recognize their value in meeting their specific needs and improving agricultural practices.

The ability of extension services to narrow the knowledge gap between farmers and researchers is a critical component of agricultural development in many developing countries. According to Van den Ban and Hawkins (1998), these services help people become more aware of ways to increase farm yields, which in turn raises their income and standard of living. According to Picciotto and Anderson (1997), effective agricultural extension systems constantly update and improve their strategies in response to new research knowledge that is in line with farmers' requirements. Public extension services have, however, frequently come under fire for failing to adapt to the various demands of farmers, failing to inspire beneficiaries to take an active role in their programs, and having limited quality of field employees (Idachaba, 2005).

Considering the difficulties involved with public extension systems, there has been an increase in interest in enlisting the private sector to provide extension services as a solution to these limitations (Okoro et al., 2006). It is unclear if the implementation of a fee-paying extension system will increase efficiency, equity, and efficacy in assisting both commercial and subsistence farmers. Farmers' willingness to pay for extension services is influenced by a number of variables, including the severity of the issues that these services can address and their financial benefits (Singh and Narain, 2016).

Exploring several paradigms and models, such as the innovation-diffusion model, the economic constraints model, and the adopter's perception model, is crucial to understanding the dynamics of farmers' willingness to pay for agricultural extension services. These paradigms consider factors such as the efficacy and relevance of extension services, how benefits are perceived, the size of farms, and farmers' educational backgrounds. According to Adesina and Baidu-Forson (1995), efficient extension services should be tailored to farmers' requirements and give them the information they need to make informed decisions. This would help to reduce poverty and enhance farmers' standard of living.

Many developing countries, including Nigeria, have recently reviewed and strengthened their extension systems in response to the realization of the critical importance of agricultural extension in ensuring food security and rural development. The effectiveness of these redesigned systems depends on farmers' readiness to pay for these services, making the assessment of farmers' willingness to pay a critical aspect of extension planning and implementation

Against this backdrop, this paper undertakes a comprehensive review of research conducted on the willingness of Nigerian farmers to pay for extension services, aiming to provide valuable insights and suggest a path forward for agricultural extension programs in the country. The study encompasses several key objectives: examine the historical trends in agricultural extension services in Nigeria; evaluate extension policies and programs in Nigeria; ascertain farmers willingness to pay and the factors that influence farmers' WTP for agricultural extension services in different regions of Nigeria; identify the common challenges and barriers faced by farmers that hinder their willingness to pay for extension services and; identify gaps in the existing literature on WTP for extension services in Nigeria and suggest areas for future research.

Historical Development of Agricultural Extension in Nigeria

Agricultural extension services have long played a pivotal role in engaging rural farming households, both within Nigeria and on a global scale. Nevertheless, the terrain of agricultural extension in Nigeria has undergone dynamic transformations, necessitating heightened participation and financial support from the private sector (Oladoja, 2004). Historically, the Nigerian government has been a central contributor to the funding and administration of extension services, with origins dating back to the pre-independence era. In response to the challenges faced by the agricultural sector, various government programs and initiatives have been introduced to revitalize this essential sector (Alabi and Mafimisebi, 2004).

Pre-Colonial and Colonial Periods:

In the period before colonial rule, farmers independently selected and introduced improved crop varieties and animal breeds, often through interactions with neighboring communities and trans-Saharan traders (Williams, 1978). Traditional agricultural practices relied heavily on apprenticeships, with knowledge being passed down through generations. During the colonial era, agricultural development initiatives were launched to boost production. In 1893, the Department of Botanical Research was established, and in 1905, the British Cotton Growers Association initiated cotton cultivation at Moor Plantation, Ibadan. By 1921, a unified Department of Agriculture was formed after the amalgamation of Northern and Southern Nigeria, with a primary focus on increasing the production of export crops for the British market (Williams, 1978).

Post-Colonial Agricultural Extension:

The post-colonial period in Nigeria can be categorized into two main groups: government-organized agricultural programs and those organized and sponsored by private entities. Government-led initiatives encompass the National Accelerated Food Production Project (NAFPP), Agricultural Development Projects (ADP), Operation Feed the Nation Programme (OFN), River Basin Development Authority (RBDA), and various other programs designed to enhance agricultural productivity (Omotayo, 2004). Additionally, private organizations such as the Nigerian Tobacco Company (now British American Tobacco Nigeria), oil companies like Shell Petroleum Development Company, religious institutions like the Catholic and Anglican churches, and non-governmental organizations (NGOs) like the Leventis Foundation have contributed to offering extension services. International organizations including the World Bank, International Fund for Agricultural Development (IFAD), United States Agency for International Development (USAID), Technical Centre for Agricultural and Rural Cooperation (CTA), and Food and Agriculture Organization (FAO) of the United Nations have also actively participated in agricultural extension and rural development in Nigeria. Private processing and marketing companies have also been integral to the extension framework, providing farmers with credit, inputs, and advisory services (Alam et al., 2013).

The evolution of agricultural extension in Nigeria witnessed a transition from the conventional Ministry of Agriculture extension system during the post-colonial national government era to the Agricultural Development Project Extension System (ADPs) in the 1970s. The ADP system introduced the Training and Visit (T and V) extension approach, characterized by professionalism, time-bound schedules, concentrated efforts, regular training, and manageable agent-to-farmer ratios. In 1990, the Unified Agricultural Extension System (UAES) emerged as a modification of the T and V system, allowing for a single Village Extension Agent (VEA) to provide extension services across various agricultural sectors (Okwu and Ejembi, 2001).

Government Institutions Supporting Agricultural Extension:

The Federal Government of Nigeria actively supports agricultural extension through several institutions, including the Project Coordination Unit (PCU), Agricultural Projects Monitoring and Evaluation Unit (APMEU), National Agricultural Extension and Liaison Services (NAERLS), and the Agricultural and Rural Management Training Institute (ARMTI). These entities provide coordination, monitoring, multimedia materials development, and management training for agricultural personnel (Ladele *et al*., 2002, and Adegbola and Bamishaiye, 2013).

Extension Policies and Programs in Nigeria:

Extension activities in Nigeria have historically lacked clear plans and coordination. They have often been treated as secondary to agriculture, lacking a dedicated policy framework. For instance, the Training and Visit (T&V) system, while initially promising, faltered once World Bank sponsorship was withdrawn due to its lack of government ownership and legal backing. This inconsistency has hindered the effectiveness of extension services (Osuntogun and Olufokunbi, 1986).

Agricultural extension policies play a crucial role in guiding decisions and investments in this field. In Nigeria, several policies have been implemented over the years to promote agricultural extension. One of the earliest initiatives was the Agricultural Development Projects (ADPs), established in 1975 to address declining agricultural productivity. However, a comprehensive agricultural extension policy was not in place until the Unified Agricultural Extension Services (UAES) policy in 1991. While it aimed to improve extension services, it fell short in addressing coordination, institutional arrangements, collaboration, and funding (USAID, 2010).

A significant step came with the 2001 Agricultural (Extension) Policy, which was a marked improvement over previous policies. It expanded beyond self-sufficiency to encompass national food security, allocating roles and responsibilities to various stakeholders, including state governments. The state governments were tasked with enhancing primary agricultural production and providing effective extension services, among other responsibilities. However, implementation challenges at the state level persisted (FMARD, 2012).

A more recent development is the Agricultural Extension Transformation Agenda (AETA), introduced as part of the Agricultural Transformation Agenda (ATA) in 2012. AETA aimed to modernize agriculture and transform the extension system into a demand-responsive, market-oriented, and technology-driven service. It emphasized the roles of different stakeholders and built on the 2001 Agricultural Policy, bringing a more pluralistic approach to extension services (FMARD, 2011).

Nigeria has seen a series of agricultural extension policies and programs over the years, with each attempting to address the challenges and needs of the agricultural sector. The 2001 Agricultural Policy and the subsequent AETA have marked significant milestones in defining roles and responsibilities and moving towards more effective extension services. However, challenges in implementation at the state level continue to impact the overall success of these policies (Issa & Issa, 2013; Naswem & Ejembi, 2017; Oyelami et al., 2018

A Review of Farmers' Willingness to pay and Factors influencing Willingness to pay for Extension Services in Nigeria.

In their study, Paparrizos, Kumar, and Ludwig (2021) investigated the willingness of farmers in Bangladesh to pay for participatory climate information services (CIS). The findings revealed a substantial willingness to pay among farmers, with over 90% in the experiment group expressing their willingness to pay in co-developed CIS. This contrasts with the 75% willingness observed in the control group. The annual subscription fees farmers were willing to pay ranged from 970.92 taka ($11.45) to 1387.20 taka ($16.36). These results underscore the high potential for participatory CIS, emphasizing the need for government and private sector involvement to develop CIS tailored to smallholders' needs.

Similarly, Mwaura, Muwanika, and Okoboi (2010) conducted a study in Uganda to assess farmers' willingness to pay for extension services. Their findings revealed that approximately 35% and 40% of farmers engaged in crop and animal husbandry, respectively, were willing to pay an average of Ugandan shillings 3,400 ($1.8) and 3,700 ($2) per trip for extension services. Interestingly, the demand for extension services was found to be relatively low when considering private sector engagement.

In Benin and Togo, Agossou *et al*. (2023) explored the determinants of farmers' willingness to pay for improved cultivars of Macrotyloma geocarpum. Their study revealed that more than 90% of respondents expressed a strong willingness to pay for improved seeds of Macrotyloma geocarpum. Factors influencing the amount farmers were willing to pay included the low yield of current cultivars, the expected yield of the improved variety (set at over 1 ton per ha), socio-linguistic group affiliation, and the adoption of improved agricultural technologies.

In Nigeria, Akinnagbe and Adesina (2018) investigated the willingness of farmers in Ondo State to pay for Agricultural Extension Services. Their findings revealed that approximately 57% of respondents were not inclined to pay for specified extension services due to factors such as low income from farming and the inconsistency of government policies. However, about 43% were willing to pay for certain services like personal visits and information on funding sources. Conversely, Umar *et al.* (2012) assessed the willingness of farmers in Niger State to pay for demand-driven extension services. Their study showed that the majority of respondents (81.2%) were willing to pay for extension services and were prepared to make cash payments. The mean annual amount respondents were willing to pay for extension services was ₦14,991. Factors such as farm size, the degree of commercialization of crop enterprises, and farm income significantly influenced this willingness to pay.

Furthermore, Onuche et al. (2015) analyzed the willingness of small-scale fish and crop producers in Kogi State, Nigeria, to pay for Agricultural Extension Services. Their findings indicated that farmers were willing to pay an average of 1.8 USD per month for extension services. Various factors influenced this willingness, including education, income, farm size, confidence in the present extension system, and extension contacts.

The factors influencing the willingness to pay for extension service delivery was examined by Akinyemi *et al.* (2019) among crop farmers in Katsina State, Nigeria. They employed a probit model for data analysis, and the results revealed that farmers were willing to pay for extension services. The factors influencing willingness to pay for extension services as revealed by the study include age of the farmers, farmer's income, the proportion of commodities sold, land ownership and household size. As a recommendation, the study suggests the implementation of efficient marketing mechanisms for farmers' produce. This can potentially enhance the overall effectiveness of extension services and benefit both farmers and the agricultural sector. Okere *et al.* (2021) assessed the willingness of smallholder oil palm farmers in Edo State, Nigeria, to pay for extension services. The study found that factors such as age, marital status, household size, transportation cost, and distance from extension service points influenced the likelihood of paying for these services. Conversely, factors like education, farm size, farming experience, income, availability of extension services, and extension visits increased the likelihood of willingness to pay.

In Kwara State, Nigeria, Falola et al. (2012) investigated the willingness of fish farmers to pay for Agricultural Extension Services. Their study identified factors affecting willingness to pay, including stock size, nature of production, level of education, and age of the farmers. The study recommended improved extension services and the encouragement of fish production among young, educated individuals.

Lastly, in a study conducted by Onoh *et al.* (2014) in South-Eastern Nigeria, researchers aimed to understand the factors influencing farmers' willingness to pay for agricultural extension services. The study revealed that factors such as the level of education, farm size, income, and farming experience had a direct relationship with farmers' willingness to invest in extension services. Specifically, farmers with higher levels of education, larger farms, higher incomes, and more experience in agriculture were more inclined to pay for extension services.

Collectively, these studies provide valuable insights into farmers' willingness to pay for agricultural extension services, highlighting regional variations, influencing factors, and potential implications for policy and service development. Nevertheless, there exists a research gap regarding the specific types of extension services that farmers are willing to pay for and how the effectiveness of these services impacts their willingness to invest. Additionally, most of the studies are region-specific, suggesting the potential for future research to conduct comprehensive national-level studies in Nigeria and other countries to gain a more holistic understanding of farmers' preferences and willingness to pay for agricultural extension services.

Constraints to willingness to pay for Extension Services in Nigeria

The study by Onoh et al. (2014) identified several constraints affecting farmers' willingness to pay for extension services, including the prevalence of free government extension services, scarcity of farm inputs, prior agricultural training received by farmers, and financial incapability. Akinnagbe and Adesina (2018) highlighted additional constraints, such as low income from farming, inconsistency in government policies, the absence of a clearly defined institutional framework, corruption and nepotism, poor basic infrastructure like road networks, an unfavorable environment for farmer participation in extension funding, and the inadequacy of ready-made markets for increased farm outputs resulting from improved extension services.

Olajide and Oyebode (2020) discussed constraints related to the practicability of services offered by one-stop agricultural extension delivery support centers. These constraints include skepticism regarding government policies, concerns about policy stability, and past failures of similar programs, which pose potential threats to the success of extension services.

WAY FORWARD:

Moving forward, several critical considerations emerge for improving agricultural extension services in Nigeria:

Policy Implementation: There is a need for improved policy implementation, particularly at the state and local government levels. Efforts should be made to ensure that policies are translated into practical actions that benefit farmers on the ground.

Tailored Extension Services: Extension services should be tailored to meet the specific needs of different regions and farming communities. A one-size-fits-all approach may not be effective, given the diversity of Nigeria's agricultural landscape.
Technology Integration: Embracing modern technology, such as digital platforms and mobile applications, can enhance the delivery of extension services. These technologies can facilitate information dissemination and real-time support to farmers.
Public-Private Partnerships: Collaboration between the public sector, private organizations, NGOs, and international agencies should be encouraged. These partnerships can bring diverse resources and expertise to the extension system, expanding its reach and impact.
Research and Data: Continued research is essential to understand evolving farmer needs and preferences. More studies should be conducted to explore the specific types of extension services that farmers are willing to pay for and the impact of service effectiveness on willingness to pay.
Capacity Building: Training and capacity building for extension workers and agents should be prioritized to ensure they have the knowledge and skills required to effectively support farmers.
Market Linkages: Extension services should not only focus on production but also on marketing and value chain linkages. Helping farmers' access markets for their produce can significantly enhance their income.
Community Engagement: Involving farming communities in the design and implementation of extension programs can lead to a sense of ownership and improve program outcomes.
Monitoring and Evaluation: Robust monitoring and evaluation mechanisms should be established to assess the impact of extension services continually. This feedback loop can guide program improvements.

CONCLUSION

In conclusion, this comprehensive review highlights the intricate landscape of agricultural extension services in Nigeria, with a particular focus on farmers' willingness to pay for these critical services. Over the years, agricultural extension has evolved from a government-centric model to a more diverse and pluralistic approach involving private sector actors, NGOs, and international organizations. Despite this evolution, challenges persist, affecting the effectiveness and reach of extension services.
Several key findings emerge from the analysis of various studies. Firstly, the willingness of Nigerian farmers to pay for extension services varies across regions and is influenced by a myriad of factors, including age, income, farm size, education, and farming experience. These factors interact with economic conditions, government policies, and the perceived benefits of extension services, shaping farmers' decisions to invest in them.
Secondly, the policy landscape in Nigeria has seen several shifts, from the early Agricultural Development Projects (ADPs) to the more recent Agricultural Extension Transformation Agenda (AETA). While these policies have aimed to redefine roles, responsibilities, and approaches in extension services, challenges in implementation, particularly at the state level, have posed significant hurdles.

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CASE REPORT: GANGRENOUS DERMATITIS IN PETERSON FARMS IN UMUAHIA SOUTH OF ABIA STATE.

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ABSTRACT
*Gangrenous dermatitis is a bacterial disease seen in turkeys and chickens caused by Clostridium septicum, C perfringens type A, and Staphylococcus aureus , either singly or in combination. It presents increased mortality in the flock. Physical examination, presents ruffled feather, somnolence, droopy wings, lethargy, i n appetence while Post mortem examination revealed; Greenish discoloration of the shank, dark reddish purple to green, weepy areas of the skin of the abdomen, pectoral muscle and neck areas. Areas of affected dermis and subcutis were characterized by extensive blood-tinged edema with congestion of the entire pectoral and abdominal areas. There was a foul smelling odour. Birds that died in the morning hours were already putrid by 12 noon. This disease is primarily a disease of broilers of over 4 weeks of age which is typical of this case. The battery cage system being operated in this farm is rarely used in broiler production because of the fragile nature of the birds and the early age at which the birds were transferred is a risk factor. Although it has got its merits in effective utilization of the available space hence holding more birds than the deep litter system, it is not a common practice. This case of gangrenous dermatitis is linked to injuries sustained during transfer to the battery cages. Samples were collected aseptically and submitted for microbiologic culture and isolation of the organisms .Result showed heavy growth of Staphylococcal species. Clostridium could not be cultured because of its fastidious nature and special media requirement. Gangrenous dermatitis was confirmed. Treatment with Oxytetracycline inj. long acting 20mg/kg I/M given at the 4th week was effective.***

Keywords: *Gangrene, dermatitis, Clostridium and staphylococcus*

INTRODUCTION
Synonyms of Gangrenous dermatitis: Necrotic dermatitis, Clostridial dermatitis, Gangrenous cellulitis, Gangrenous dermatomyositis, Gas edema disease (Kahn, et al., 2010). Gangrenous dermatitis is a bacterial disease seen in turkeys and chickens caused by *Clostridium septicum*, *C perfringens* type A, and *Staphylococcus aureus*, either singly or in combination. Morbidity may be up to 50% and mortality is high. It occurs due to invasion of 'normal' wounds by 'normal' bacteria in immunosuppressed birds. Immunosuppression is therefore a predisposing factor, especially following congenital Chick Anaemia Virus infection or early Infectious Bursal Disease Virus infection (Gumboro Disease). The condition is characterized by rapid onset of acute mortality (McMullin, 2004; Kahn *et al.*, 2010)

METHODOLOGY
The clinical sign observed was death occurring in well-fleshed birds suddenly because the incubation period is relatively short (12–24 hours). Other clinical findings are general in nature and include depression, incoordination, in-appetence, leg weakness, ataxia, and high fever. Occasionally dejection, gangrenous skin, severe cellulitis especially of thighs, wings, and wattles. Gross lesions consist of dark reddish purple to green, weepy areas of the skin. Affected areas included abdomen, breast, wings, or legs.

Areas of affected dermis and subcutis are characterized by extensive blood-tinged edema, with or without gas (crepitus). Infection may extend into underlying musculature, which may be discolored and contain edema and gas.

Diagnosis was based on clinical signs and/or lesions which are almost pathognomonic (Jordan, and Pattison., 1996). Diagnostic confirmation is based on the presence of lesions and recovery of an abundant growth of causative agent(s) from affected tissue of recently dead birds (McMullin, 2004).

Gangrenous dermatitis has historically been treated effectively with administration of many broad-spectrum antibiotics. Water acidifiers have been used in cases to reduce, but not eliminate mortality where mortality rates are low or antibiotic efficacy has been poor (Kahn *et al*., 2010; Chauhan and Sushovan., 1996). Prevention and control involves good hygiene and management. Avoid skin trauma and immunosuppression (congenital Chicken Anaemia Virus infection, early Infectious Bursal Disease Virus infection). Total cleanout and disinfection of affected houses has reduced or eliminated gangrenous dermatitis infection on farms with historical problems. Salting of floors has also reduced bacterial challenge in subsequent flocks. Reducing excessive moisture and microbial levels in poultry house litter and minimizing trauma are useful adjuncts to other prevention and control measures. Where infection is secondary to predisposing viral infection, modification of vaccine programs directed at immunosuppressive agents may be used to control widespread gangrenous dermatitis (McMullin., 2004, and Kahn, *et al*., 2010,; Jordan and Pattison., 1996).

Species affected: Avian. Breed affected: Aborika. Farm population of birds: 10,000 AGE: 6 Weeks plus

Primary complaint: The farmer reported that birds in his farm started dying few weeks ago.

Case history: Birds were transferred through four pens before they arrive to the battery cage system at 5th week. The transfer was done weekly. The vaccination programme was up to date. Observation showed that the birds affected are the ones kept on battery cage system of poultry production. The ones kept on deep litter were not affected. The birds died soon after they showed signs of disease. Dead birds presented skin discoloration. They had been treated previously with Ciprofloxacin and EST MIX® at different occasions prior to our invitation.

On physical examination of the birds during the necropsy examination, the following were observed; Ruffled feather, somnolence, droopy wings, lethargy, Inappetence. Post mortem examination conducted revealed; greenish discoloration of the shank, dark reddish purple to green, weepy areas of the skin of the abdomen, pectoral muscle and neck areas. Areas of affected dermis and subcutis were characterized by extensive blood-tinged edema with congestion of the entire pectoral/ abdominal areas. There was a foul smelling odour. Birds that died in the morning hours were already putrid by 12 noon we arrived.

Sample for Diagnosis

The following samples were aseptically collected; liver, haemorrhagic/congested area of the pectoral and thigh muscle, fat sample at the perineal area and submitted for microbiologic culture and isolation of the organisms.

Differential Diagnosis was Chick anaemia virus and Alvian influenza virus.

Tentative Diagnosis was Gangrenous dermatitis based on clinical signs and post mortem lesion.

Laboratory Test Result showed heavy growth of Staphylococcal species. Clostridium could not be cultured because of its fastidious nature and special media requirement.

Confirmatory Diagnosis was Gangrenous dermatitis.

RESULTS

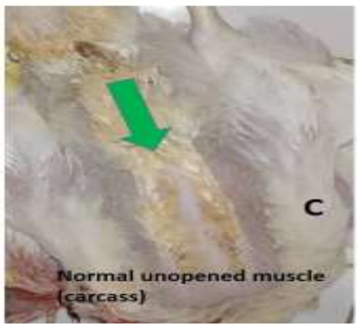
The case presented was a case of ganreneous dermatitis

Treatment: Oxytetracycline Inj. long acting 20mg/kg I/M given at the 4th week. Withdrawal period was strictly adhered to according to Aliu, (2007).

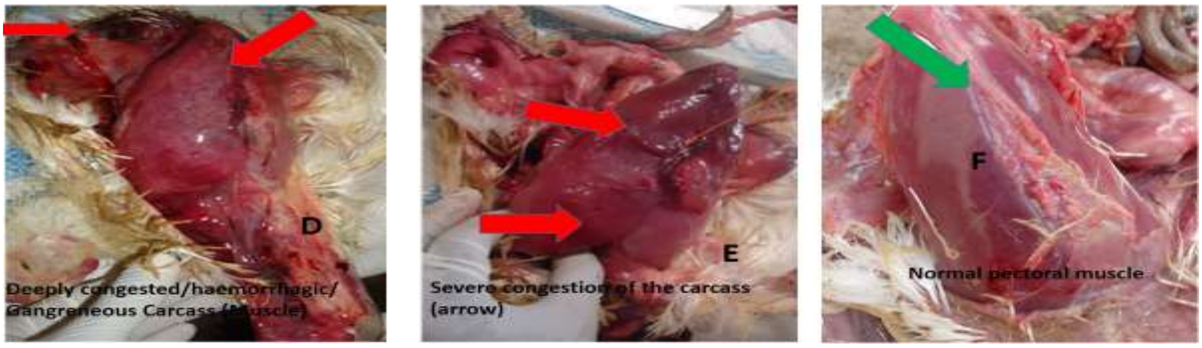
Rationale for therapy: Tetracycline is so effective in the treatment of clostridial diseases and most common bacterial disease of poultry (Aliu, 2007).

Severely gangrenous unopened Carcass (see arrow)

Gangrenous unopened pectoral muscle and lower abdomen (see arrow)



Normal unopened muscle (carcass)



DISCUSSION

Gangreneous dermatitis presents increased mortality in the flock. Clinical signs and post mortem lesions seen in this case agrees with that described by Jordan and Pattison (1996) and Chauhan and Sushovan (1996).(plate A, B,D AND E).

Both *Clostridia and Staphylococci* are ubiquitous in the poultry house environment and in (intestine) or on skin of the birds. Gangrenous dermatitis often is believed to occur as a sequela of other diseases that produce immunosuppressive effects such as Infectious bursal disease, Chicken infectious anemia, Reticuloendotheliosis, Reovirus, and Inclusion body hepatitis. Environmental conditions that promote poor litter conditions may also predispose flocks to gangrenous dermatitis, especially when present in conjunction with challenges from immunosuppressive viruses. Failure to remove moribund or dead birds as soon as it occurs may increase incidence of the disease, because such birds serve as reservoirs of the causative agent(s). Management practices that lead to wound, overcrowding, feed outages, irregular time of feeding may increase incidence of infection. Affected farms tend to have repeated outbreaks if the environment is not treated (McMullin, 2004, and Kahn *et al*., 2010)

Gangrenous dermatitis is primarily a disease of the broiler over 4 weeks of age which is typical of this case. Mortality can reach 8-9% in untreated cases (Jordan and Pattison, 2007). The battery cage system being operated in this farm is rarely used in broiler production because of the fragile nature of the birds and the early age at which the birds were transferred is a risk factor. Although it has got its merits in effective utilization of the available space hence holding more birds than the deep litter system, it is not a common practice. This case of gangrenous dermatitis is linked to injuries sustained during transfer to the battery cages.

RECOMMENDATION

There should be careful transfer of birds to reduce injuries especially in the battery cage system being operated in this case. Infectious bursal disease vaccination should be modified; removal of moribund or dead birds as soon as possible, avoidance of overcrowding, feed outages and inconsistent feeding time to avoid undue struggle for feed is highly recommended.

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ASSESSMENT OF THE ADOPTION STAGES OF IMPROVED SWEET POTATO PRODUCTION TECHNOLOGY IN OTUKPO LOCAL GOVERNMENT AREA OF BENUE STATE, NIGERIA

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ABSTRACT
The study assessed the response of farmers to the adoption stages of improved sweet potato production in Otukpo LGA of Benue State, Nigeria. Otukpo was purposely chosen because of its nearness to National Root Crops Research Institute (NRCRI), Umudike which has its national mandate of researching on root and tuber crops. Well structured questionnaire was used to collect the samples at random. Two districts out of four were used. One hundred and eighty (180) farmers were randomly selected for the study. Frequency distribution table and line graph were used to analyze the data. The result showed that 40% of the farmers were aware of the technology, while 31%, 18%, 6% and 5% were interested, tried, adopted and unaware of the technology respectively. The study therefore called for policies that would increase the adoption level of the production in the area, thus, practical knowledge and sweet potato value addition like confectioneries and drinks are recommended.
Keywords: *Sweet potato adoption stage,*

INTRODUCTION
Sweet potato *(Ipomea batatas*) is dicotyledonous plant that belongs to the bindweed or morning glory family, Convolvulaceae. The plant is a herbaceous perennial vine, bearing alternate triangle-shaped or palmately lobed leaves and medium-sized sympetalous flower. It is a cover crop that is usually grown for its edible underground root, and leaf. Its large, starchy sweet-taste tuberous roots are used as a root vegetable while the young shoots and leaves are sometime eaten as leafy vegetable. However, many authors have referred sweet potato as an economic important crop due to its relevance in both home consumption and industrial uses.

The root is produced industrially for making flour, cake, chips, doughnut, and bread as well as starch for textile (Nwankwo *et al*., 2021). According to Truong *et al*., (2018), the beta-carotene in sweet potato (Orange fleshed sweet potato) is a nutritional content that is capable of defeating the war against vitamin A deficiency in our society. Furthermore, the studies of (Low *et al.*, 2007; Hotz *et al.*, 2012) indicated that increased consumption of orange-fleshed sweetpotatoes improved the vitamin A status of children, pregnant women, and lactating mothers. In the world food map, sweet potato ranks the fifth most important food crop in the tropics and the seventh in the world food production (FAO, 2016). El-Sheikha and Ray (2017) reported that Sweet potato has the capacity to fight hunger in our society by meeting up the family food requirements, reducing poverty, and increasing food security of a nation.

Sweet potato is highly productive crop in Southern and Northern part of Nigeria especially when all the agronomic practices accrue to it are adopted and applied. The crop according to Nwankwo and Bassey (2021) adapts to a wider range of climatic and soil conditions in both Northern and Southern part of the country. Sweet potato thrives well in the Southern part of the Nigeria despite of high amount of rain fed and acidity level in the region (Nwodo, 2008). Despite its relevance in combating the food insecurity and generation of income to farmers, many farmers are yet to adopt it as one of their major food crops. This study, therefore tend to address the level of adoption of the sweet potato technology in the study area.

METHODOLOGY
Study Area
The study was carried out in Otukpo Local Government Area (LGA) of Benue State. The Local Government Area is a tropical savanna climate with a longitude of 7` 11` 35 North and 8` 8` 47 East, Latitude of 1'19306-8'14639 and Altitude of 207m. it comprises of four district namely; Otukpo, Ugboju, Adoka and Akpa. The LGA bounds with some other LGAs; Apa LGA to the North, Obi, Ado and Okpokwu to the South, Gwer west and East to the

East and to the West is Ohimini LGA. The LGA is mainly known for rice, yam, cassava, quinea corn and maize productions as the major staple.

Sample Selection

Samples selection was based on the districts, communities and farmers. From the four district in Otukpo LGA, two (Otukpo and Akpa) were selected for the study because of their close vicinity to National Root Crops Research Institute, Otobi Sub-station. Nine (9) communities from each of the selected district were selected, hence, a total of 18 communities were selected. From each of the community, ten (10) farmers were selected and therefore a total of one hundred and eighty (180) farmers were selected for the study.

Data Analysis

A frequency table and graph chart was used to assess the responsiveness of farmers to adoption stage in the study area.

RESULTS AND DISCUSSION

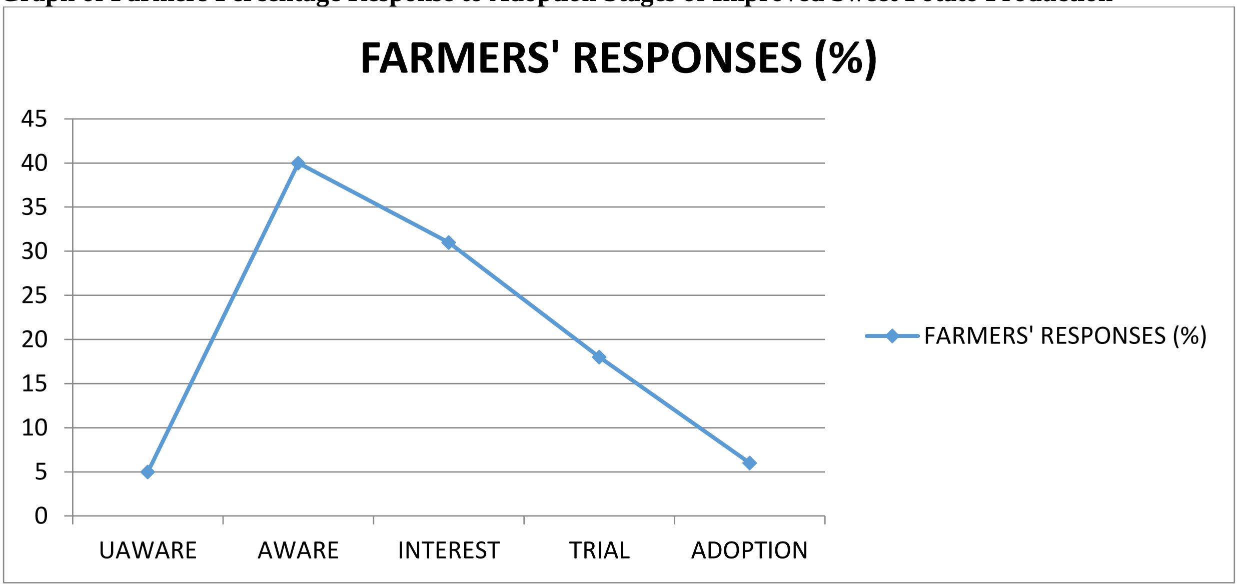
Table 1 shows the responses of farmers towards adoption stages in the study area are represented on the graph above. The result showed that 5% of the farmers were unaware of the technology while 40% of the farmers were aware and is an indication that the larger population of the farmers in the area was acquainted with the knowledge of the production of the improved sweet potato. The high level of awareness of the technology could also be attributed to the practical orientation gotten by the farmers from the Research Institute domiciled in the region. According to Madhu *et al.* (2020), management orientation through extension activities inspires farmers to be aware and know more about the scientific advantages of soil health card in Mandya District of Karnataka.

Table 1: Farmers Responses io Adoption Stage

S/N	ADOPTION STAGES	PERCENTAGE OF RESPONSE (%)
1	UAWARE	5
2	AWARE	40
3	INTEREST	31
4	TRIAL	18
5	ADOPTION	6

SOURCE: SURVEY 2021

Graph of Farmers Percentage Response to Adoption Stages of Improved Sweet Potato Production



However, there is a sharp decrease from 40% to 5% as shown on the graph above. Farmers lost interest on the technology which resulted to low level of trial and adoption by them. This therefore, could be attributed to the fact that the farmers have alternative staple foods which might have more relative economic advantage than the sweet potato. Research evidence indicates that if a potential user sees no relative advantage in using the innovation, it will not be adopted Greenhalgh *et al.* (2004).

SUMMARY AND RECOMMENDATION

The result showed that 40% of the farmers were aware of the technology, while 31%, 18%, 6% and 5% were interested, tried, adopted and unaware of the technology respectively. This therefore, implied that awareness creation is not enough parameter for technology adoption but additionally, practical demonstration that will enable the farmers to try what they learnt is recommended. Also the sweet potato value addition like confectioneries and drinks is recommended as policy that would boost up its production in the area and beyond.

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COMPARATIVE ANALYSIS OF THE ROOT YIELD OF TWO NEWLY RELEASED CASSAVA VARIETIES USING DIFFERENT PLANTING METHODS IN UMUDIKE, ABIA STATE, NIGERIA

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ABSTRACT
Cassava is a popular crop in tropical countries, providing a reliable source of food during the lag period between planting and harvest. It is drought-tolerant and can grow in marginal soils with low fertility and rainfall. Over 800 million people globally consume cassava and its products, especially in Sub-Saharan Africa. However, the seed industry in Nigeria is still nascent, especially in crops like cassava with low propagation and development cycles. Cassava can generate about 5-10 stem cuttings per plant, which is low compared to grains like rice, maize, and cowpea. The development cycle of cassava is one year, putting it at a disadvantage in seed yield compared to grains. The study aims to evaluate the seed yield of newly released cassava varieties under varied planting methods and the economic returns of planting materials obtained from two cassava varieties. The study aims to identify which varieties will yield more returns to farmers interested in commercial cassava seed enterprise. The study was conducted at the National Root Crops Research Institute Umudike's Western farm using a 2x2 factorial design and a Randomized Complete Block Design (RCBD). The experiment involved two newly released cassava varieties (Dixon and Poundable) and two planting lengths (L1=25cm, L2=12.5cm). Data was collected from sprout count, plant height at harvest, number of roots per plot, root weight per plot, number of stem per plot, stem weight per plot, biomass weight per plot, number of rots per plot, total root yield per plot, and total seed yield. The results showed that variety significantly influenced plant height, with Poundable having a mean height of 168.7cm and Dixon having an average height of 124cm. Fertilizer rates also influenced plant height, with higher rates leading to higher plant height and seed yield. The second length of cassava cuttings (L2=12.5cm) allowed seed entrepreneurs to plant larger areas of land with the same stem yield as the first length (L1=25cm).
Keywords: *Comparative analysis, root yield, newly released varieties, cassava*

INTRODUCTION
Cassava is a popular crop grown in almost every tropical country. Its agribusiness prospects places it over several traditional staples, hence its successful incorporation into many farming and food systems on the continent. Cassava was initially adopted as a popular food security crop; this is because it provides a more reliable source of food especially during the lag period between the planting season and harvest. It is also drought tolerant and has tenacity to grow in marginal soils with relatively low fertility and rainfall (Spencer and Ezedinma, 2017). Cassava is one staple crop that requires little or no external inputs for production (Udensi *et al.*, 2011). According to Boykin *et al.* (2019) over 800 million people globally; especially in the Sub-Saharan Africa, consume cassava and products made out of cassava. In recent times, it has emerged as both staple food and profitable cash crop of industrial significance in the world economy (Aerni, 2006). The seed industry in Nigeria is still nascent especially in crops like cassava with relatively low level of propagation. Its vegetative mode of propagation is also a strong limitation to cassava production (Onunka *et al.,* 2016). According to Nurul Nahar and Tan (2012) one cassava plant can generate about 5-10 stem cuttings and this is too low compared to that of the grains like rice, maize, cowpea to mention but a few which have high multiplication ratios. Furthermore, the development cycle of cassava is one year and it puts cassava to a disadvantage in quantity of seed yield, when compared to grains whose development cycle fall between 3-5 months (Onunka *et al.,* 2016). Extant literature is the fact that varied stake length i.e. the recommended 25cm length and 12.5cm do not show any significant difference in the quantity of stem yield generated by certain cassava varieties. It is therefore imperative that among other treatments, the effect of the stake lengths on newly released varieties be evaluated. Apart from these bottlenecks already identified in the production of substantial quantity of cassava seeds, handling of the planting materials is cost intensive due to

its bulkiness. These impediments indicates that more research is needed in the seed system of the cassava value chain to tap into the numerous opportunities it provides.

Cassava enterprises in Nigeria especially the commercialization of the planting materials (seed cuttings) has a great future and can significantly contribute to the reduction of hunger, unemployment and poverty now that these challenges are being addressed. Furthermore, the crashing of crude oil in the global oil market make it extremely difficult for Countries like Nigeria to solely depend on it in running their economy. There is lack of knowledge of the total output of stem cuttings and the economic returns per variety of cassava per hectare. Coupled with the fact that these cassava-planting materials come in diverse architectural build, some have two or three stems per stand, while others have initial and apical branches and these places varieties at advantage over others. The question therefore is which varieties will yield more returns to the farmer who wants to go into commercial cassava seed enterprise. This study therefore seeks to evaluate the seed yield of all the varieties, the economic returns of planting materials obtained from two cassava varieties by looking at the number of stem cuttings derivable from each selected cassava variety, the number of bundles that can be derived from a selected cassava variety and determine the total returns from the stem cuttings from each selected variety. Hence, there is need to evaluate the seed yield of some newly released cassava varieties under varied planting methods and the economic analysis of the seed yield.

MATERIALS AND METHODS

Study Area: The study was carried out in the Western farm of National Root Crops Research Institute Umudike. The experimental design is a 2x2 factorial design implemented within a Randomized Complete Block Design (RCBD). The factors considered in this design are variety and length of cuttings, each with two levels, respectively. The experiment was replicated three times. The treatment combinations include:

- Two newly released cassava varieties (Dixon (V1) and Poundable (V2))
- Two planting Lengths (L1=25cm, L2=12.5cm)

Data Collection

Primary data generated covered sprout count at 1WAP and 1MAP, plant height at harvest (cm), number roots per plot, root weight per plot, number of stem per plot, stem weight per plot, biomass weight per plot, number of rots per plot, total root yield per plot and total seed yield. These data was subjected to analysis using simple descriptive statistics such as graphs and Analysis of Variance (ANOVA) was employed.

RESULTS AND DISCUSSION

Effect of variety type on plant height

The result of the analysis showing the effect of variety on plant height is shown in Figure 1. The result indicates that variety influenced plant height significantly (P<0.005). Poundable which is one of the newly released varieties had a mean height of 168.7cm whereas Dixon had an average height of 124cm. Variety is therefore shown to influence overall yield of the stem. This is in accordance with a-priori expectation as most cassava varieties are phenotypically taller while others are shorter. This corroborates the findings of Dimkpa *et al.* (2021), who found out that the height of eight out eleven cassava varieties were taller in a study to determine their growth performance and susceptibility to some insects and diseases in humid tropics in River State.

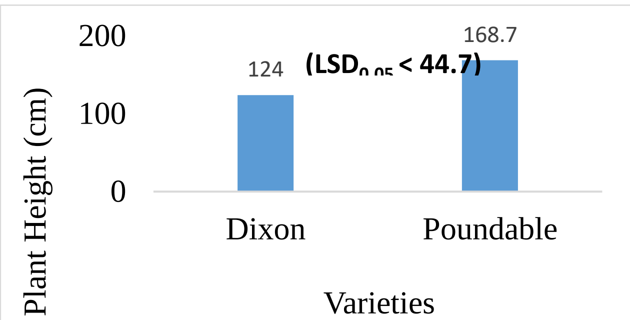


Figure 1. **Effect of fertilizer rates on plant height**

Figure 2 shows the effect of fertilizer rate on plant height. According to the result, the effect of different rates of fertilizer application on plant growth shows that R3 (800kg) gave the highest (160.6cm) followed by R2 (400kg) with the height of 152.7cm and R1 (200kg) with the height of 145.8cm respectively. This is in line with a-priori expectation and agrees with the study by Temegne *et al.* (2019), on appropriate fertilizer rates for cassava production in the humid forest agro-ecological zone of

Cameroon. This implies that holding other treatments constant, the higher the fertilizer rate, the higher the plant height, which also influences the seed yield.

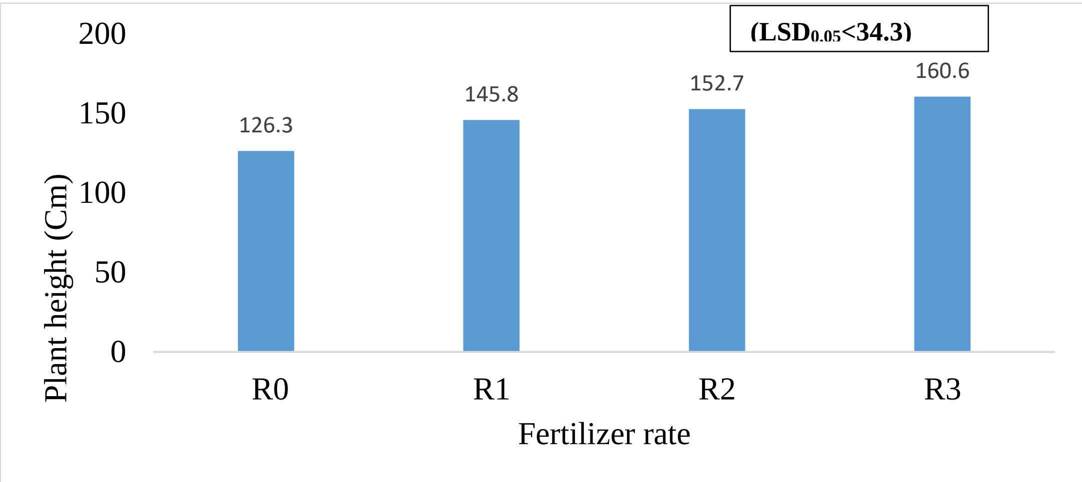


Figure 2: Effect of fertilizer rates on plant height.

Effect of length of cassava cuttings on plant height

The result of the analysis on the effect of length of cassava cuttings on plant height as presented in Figure 3 shows a difference in the mean of L1 (25cm) which is the recommended length and L2(12.5cm). Both had 148.9cm and 143.8cm means respectively. However this difference was not statistically significant at $p<0.05$.

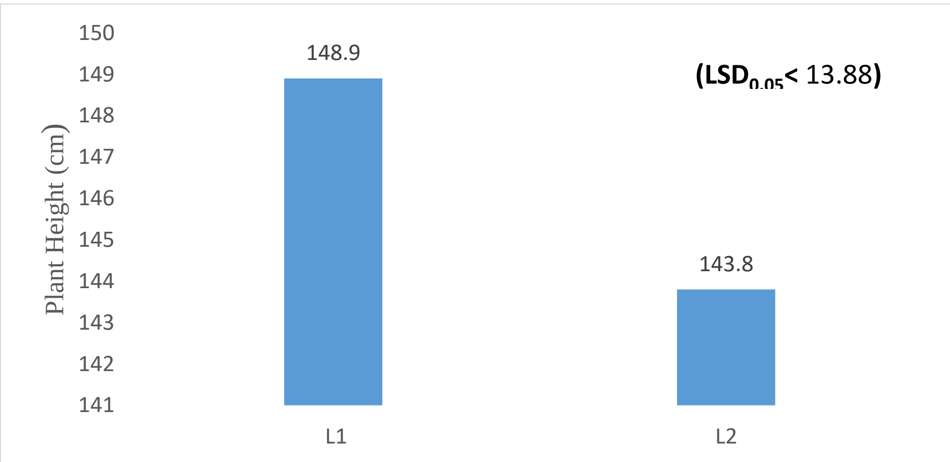
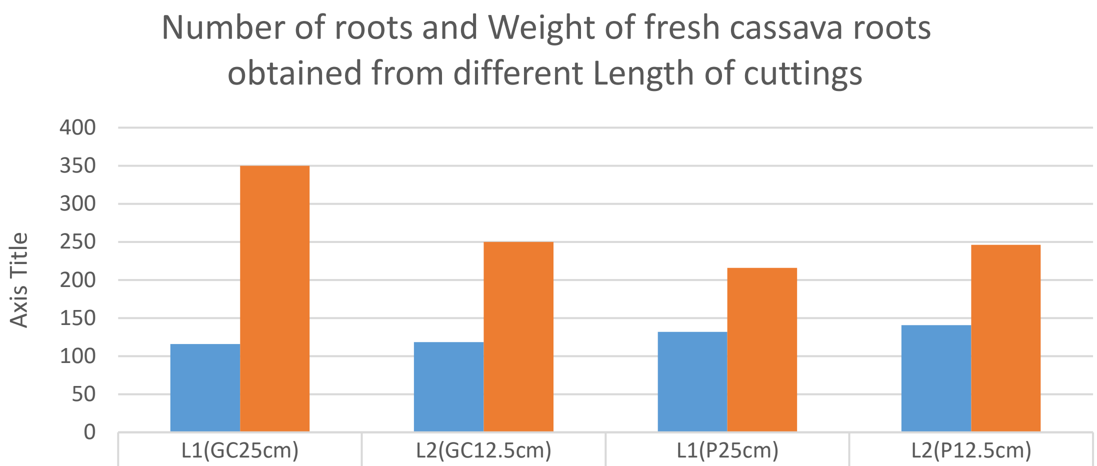


Figure 3: Effect of length of cassava cuttings on plant height

The implication is that a seed entrepreneur could use the second length (L2=12.5cm) which gives the entrepreneur twice the quantity of cuttings that could be used to plant up larger area of the land and still get the stem yield that is obtainable with (L1 =25cm). This finding corroborates the study of Onunka *et al.* (2016), who found that a particular cassava variety (TME419) generated much quantity of cassava cuttings, the length of stakes notwithstanding. Effect of length of cassava cuttings on the number of roots and weight obtained from the two cassava varieties

The result shows that for game changer, the highest number of roots (350) was obtained from L1 (25cm) while L2 (12.5cm) gave 250 roots. Furthermore, the total weight of the roots gotten from L1 (25cm) was 116kg while that gotten from L2 (12.5cm) was 119kg. The implication of this outcome is that although the number of root obtained from the L1 was higher, it did not translate to higher weight and for the fresh root entrepreneur, the weight not just the number of root matters as this determines how much monetary value is attached to the produce.

For the poundable, the outcome follows a-priori expectation as the number of roots obtained in L2 (12.5cm) gave the highest weight (141kg) while that of L1 (25cm) gave 216 roots and 132kg respectively. This shows that a fresh root entrepreneur can leverage on and use the L.2(12.5cm) and still make maximum profit and also reduce cost of production.



	L1(GC25cm)	L2(GC12.5cm)	L1(P25cm)	L2(P12.5cm)
Series1	116	119	132	141
Series2	350	250	216	246

Figure 4: Effect of length of cassava cuttings on number and weight of fresh root obtained from the two cassava varieties.

CONCLUSION

From the study results, it is evident that plant height has been influenced largely by the type of cassava variety and the fertilizer rates. The effect of the stake length of cuttings was not statistically significant. Furthermore the weight of the roots obtained from the different levels of cuttings, did not show any marked difference. Hence, this paper concludes that a seed entrepreneur, given the treatments above, can actually use the second stake length i.e. 12.5cm and still get reasonable root yield as one who uses 25cm.

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SOCIOECONOMIC CHARACTERISTICS AND PERFORMANCE OF TURMERIC MARKETERS IN SOUTHEAST NIGERIA

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ABSTRACT
The study determined the socioeconomic characteristics of turmeric marketers and evaluated their performance in, South East, Nigeria. A multi-stage sampling procedure was used in selecting one hundred and ninety-two (192) respondents for the study. A structured questionnaire was used to collect data from the respondents. The data collected were analyzed using frequency distribution, net returns, marketing margin, and marketing efficiency and ols regression. The result shows that the majority of the marketers were female (65.10%) and are married; they are still in their active age. The result of the performance of turmeric marketers shows that turmeric marketing was profitable. The educational level attended by the turmeric marketer increased the performance level of the marketers. It is therefore recommended that males should be encouraged to market turmeric since it is profitable and a source of livelihood.
Keywords: *Socioeconomic characteristics, Performance, turmeric, marketers*

INTRODUCTION
Turmeric (botanically known as Curcuma longa Linn), the 'golden spice of life', is a root crop in the same family as ginger. Yet, it receives less attention from Nigerian farmers despite having enormous potential for local industries and exports. It is used in the food, cosmetic and pharmaceutical industries. It is used as a spice and is the major curry powder component. Turmeric is also used in cosmetics for its brilliant yellow and characteristic perfume. And also being used as a dye for colouring fabrics.

According to Njoku and Nwosu (2000), inadequate market information constitutes a problem for marketers as they cannot take advantage of favourable opportunities arising from price differences between producing and consuming areas. The problems of turmeric marketing include a lack of improved processing methods that can add value and increase product selling prices.The objective of the study is to determine the socioeconomic characteristics of turmeric marketers, to estimate the performance of the turmeric marketers and estimated the determinants of the performance of turmeric marketers in the study area.

METHODOLOGY
The study was conducted in the Southeast of Abia, Ebonyi and Imo of Nigeria. The areas lie between Latitude 5.4527^0N, Longitude 7.5248^0E, and Latitude 6.2649^0N, Longitude 8.0137^0E, and Latitude 5.5720^0N, Longitude7.0588^0E respectively. The states have a total land mass of 10,952,400ha. The zone has over 16 million resident populations (NPC, 2014). The zone comprises five states: Abia, Anambra, Ebonyi, Enugu, and the Imo States. It also has a rural population density of 173 persons per square kilometre. About 60-70% of the inhabitants are engaged in agriculture, mainly crop farming, animal rearing, food processing, and farm produce marketing.

A multi-stage sampling procedure was used in selecting the respondents for this study. The target population was turmeric marketers. The turmeric marketers were randomly sampled. The first stage involved a purposive selection of three states, Abia, Imo, and Ebonyi, out of the five states in the Southeast geo-political zone. These states were chosen based on their high-level activities in turmeric marketing. In the second stage, four LGAs were purposively chosen from each of the states, giving a total of twelve LGAs. In the third stage, four communities were purposively selected from each LGA, giving a sample of 48 communities. In the fourth stage, each community randomly selected one market to give 48 markets. In the fifth stage, a multi-stage random sampling technique selected three turmeric marketers from each community. It was compiled with the aid of the community residents, extension agents and turmeric marketers in the areas. This gave 144 turmeric marketers in the areas.

Primary data were collected using structured questionnaires administered to turmeric marketers. The data collected from the turmeric respondents were analyzed using descriptive statistics such as percentage, frequency distributions, mean, multiple regression techniques, marketing margin, and marketing efficiency.
Objective one was achieved using descriptive statistics such as percentage, frequency distribution, and mean. Objective two was achieved using marketing costs, net returns analyses, marketing margin and marketing efficiency models. The relationships between the models were shown using Equation 1.

$$NR = TRS - TMC \quad (1)$$

Where
NR = Net Return
TRS =Total Revenue Sales
TMC = Total Marketing Cost
The formula for calculating the marketing margin is shown in Equation 2

$$M_M = \frac{S_P - P_P}{S_P} \times \frac{100}{1} \quad (2)$$

Where
M_m =Marketing Margin
S_p = Selling Price
P_p = Purchase Price
The marketing efficiency is obtained using (Adekanye, 1988) equation 3.

$$M.E = \frac{\text{value added by marketing(Net Return)}}{\text{Total marketing cost(TMC)}} \times \frac{100}{1} \quad (3)$$

M,E =Marketing Efficiency
Objective three, estimated the determinants of performance of turmeric marketers, and was assessed using the ordinary least squares regression equation expressed implicitly in equation 4;

$$Y = f(X_1, X_2, \ldots X_{10}) \quad (4)$$

From equation (4), the model is specified in equation 5 explicitly as,

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x_7 + b_8x_8 + b_9x_9 + b_{10}x_{10} + b_{11}x_{11} + b_{12}x_{12} + U \quad (5)$$

Where,
Y = Marketing Efficiency (see equation 3)
X_1 = age (yrs)
X_2 = Gender (1=female; 0 = male)
X_3 = Educational level (yrs);
X_4 = Extension Visits (number)
X_5 = experience in processing/marketing (yrs)
X_6 = Household Size (Number);
X_7 = Membership of Cooperatives dummy (Member =1; Not member = 0);
X_8 = Distance to Source of Credit (km)
X_9 = Income (₦)
X_{10} = Transportation cost (₦)
X_{11} = Storage cost (₦)
X_{12} = Selling Price (₦)
U_i = error term

RESULTS AND DISCUSSION

The Socioeconomic Characteristics Of Turmeric Marketers

The results of the socioeconomic characteristics of turmeric marketers are presented in Table 1.

Table 1: Socioeconomic characteristics of turmeric marketers

Variables	Freq	Percentage
Sex		
Male	67	34.90
Female	125	65.10
Age (years)		
21-30	30	15.66
31-40	72	37.50
41-50	50	26.04
51-60	24	12.50
61-70	16	8.33
Mean		38.40
Marital status		
Married	103	53.65

Single	29	15.10
Divorced	25	13.02
Widow	35	18.23
Education level (years)		
No formal Education	20	10.42
Primary Education(1-6)	57	29.69
Secondary Education(7-13)	67	34.90
Tertiary Education(14-19)	48	25.00
Experience (Years)		
1-5	22	11.46
6-10	36	18.75
11-15	38	19.79
16-20	40	20.83
21-25	30	15.63
26-30	26	13.54
Mean		32.00
Household size		
1-3	45	23.44
4-6	57	29.69
7-9	55	28.65
10-12	35	18.23
Total	192	100
Mean		48.00

Source: Field survey data, 2020

The turmeric marketers in Table 1 shows that the majority (65.10%) of marketers are females. This could be because the marketing of turmeric requires less effort and less energy for women to engage in. This is in line with the findings of Ezra *et al*. (2017), which indicated that women dominate turmeric marketing due to the low demands of time and effort required to work in the enterprise. The results show that the mean age of turmeric marketers was 38.40 years. It was observed that those between the age bracket of 31 and 50 of turmeric marketers had the highest representatives (63.54%). This implies that turmeric marketers are within the active working bracket. The results obtained align with the findings of Kantiok (2007), who opined that most agricultural enterprise actors are in their working age. Also, this is in line with the findings of Udoh and Nyienakuma (2008). They opined that agriculturists within the active age groups could withstand stress and put more time into various agricultural operations.

The result of the marital status shows that the majority (53.65%) of turmeric marketers were married. This implies that turmeric marketing is a source of income to the families from which they meet their basic needs. This result agrees with Ojo and Jibowo (2008), who reported that married people are responsible, and their views are likely to be respected within the rural communities as they decide on agricultural inputs. The findings agree with the study of Bassey *et al.* (2015), who reported that most agricultural product marketers were married. The result shows that most turmeric marketers (89.54%) had one form of formal education or the other. The result shows that literacy levels among them could enhance marketing technology. This could enhance the management of the turmeric business in the study area. In marketing, formal education allows turmeric marketers to understand the

Performance of Turmeric Marketers

In this study, the performance of turmeric marketers was measured using net returns, marketing margin, and marketing efficiency. The results showing the performance of turmeric marketers are presented in Table 2. The result indicates that the turmeric marketers incurred, on average, a total cost of ₦74,290.00 and obtained an average total revenue of ₦100,000.00.

Table 2: Net returns of turmeric marketers (Average quantity per week)

Variables	Quantity (kg)	Unit Cost (₦)	Total cost (₦)
Variable cost			
The purchase price per kg	100	700.00	70,000.00
Cost of transportation		21.00	2,100.00
Cost of sorting	100	6. 50	650.00
Cost of marketing materials	100	10.30	1,030.00
Total Variable Cost			73,780.00
Fixed Cost			

Cost of Rent	100	5.10	510.00
Total Cost			74,290.00
Selling price per kg of dried turmeric	100	1000.00	100,000.00
Revenue			100,000.00
Net Return			25,710.10
Performance Indicators			
Marketing margin (%)	25.71		
Marketing efficiency (%)	34.61		
Return on Naira investment (₦)	1.35		

Source: Field survey data, 2020

The marketers made a net return of ₦ 25,710.00, meaning the turmeric marketing was profitable. The marketers had marketing margins of 25.71% and marketing efficiency of 34.61%. The result shows that marketers were efficient in marketing. The rate of return on investment of ₦1.35 for marketers' which means that for every Naira invested in the business, the marketers made a return of ₦1.35k. The result in Table 2 shows that the marketers incurred, on average, a total cost of ₦74,290.00 and obtained an average total revenue of ₦ 100,000. 00. The marketing materials used by the turmeric marketers include nylon bags, weighing balance, and sack bags.

Estimate the determinants of the performance of Turmeric marketers using ols regression.

The factors determining the performance level of turmeric marketers were achieved using the OLS regression. The results of the regression analysis are shown in Table 3

Table 3: Results on Determinants of Performance by Turmeric Marketers

Variables	Linear	Exponential	Semi-log	Double log
Constant	64.38	0.2444	-835.31	23.5208
	(3.22)***	(0.34)***	(-4.22)***	(3.30)***
Age	0.4305	0.00333	4.7765	0.2144
	(1.16)	(0.82)	(0.95)	(0.75)
Gender	-0.4231	0.01755	-7.3457	0.0133
	(-2.05)**	(0.26)	(-4.24)	(0.19)
Educational level	0.4803	0.01305	1.9447	0.0448
	(1.82)*	(1.71)*	(0.92)***	(0.75)
Extension service	0.0186	-0.00084	0.6375	0.0062
	(0.03)	(0.00)	(4.12)***	(0.07)
Experience	0.6340	-0.00355	-1.6226	0.04575
	(3.78)***	(- 0.66)	(0.82)	(0.70)
Household size	-0.4426	-0.0189	-2.2624	-0.0931
	(-1.03)	(-1.33)	(-1.08)	(-1.34)
Membership	2.8777	0.08376	3.1253	0.07015
of cooperatives	(1.36)	(1.12)	(2.73)***	(6.44)***
Distance to source	-0.0256	-0.00032	-14.5358	-0.5573
Credit	(-4.15)***	(-4.13)***	(-4.01)***	(-3.78)***
Income	0.00572	0.000253	111.105	3.4530
	(4.14)***	(4.66)	(5.03)***	(4.31)***
Transportation cost	-0.0631	-0.0042	-4.4005	-0.4254
	(-0.42)	(-8.23)	(-3.56)***	(-6.4)*
Storage cost	-0.8224	-0.1469	-3.54	-0.1423
	(-3.2)	(-2.55)	(-4.23)***	(-3.6)
Purchase price	-1.8649	-0.0403	-3.422	0.8335
	(-4.5)	(-4.3)	(-4.12)***	(1.66)
R^2	0.5443	0.4212	0.6743	0.3013
Adjusted R^2	0.4798	0.2673	0.6132	0.2357
F-stat	6.57***	5.83***	9.05***	5.11***

Source: Field survey data, 2020 ***, **, * = statistically significant at 1%, 5% and 10% respectively

The semi-log functional form of the regression was chosen as the lead equation. The reason is that R^2 values were higher than the other three functional forms. The value of F-ratio (61%) was significant at the 1.0% probability level. This indicates that the model is a good fit. The coefficient of the level of education, number of extension visits, membership of cooperative societies, and income were all significant at a 1.0% probability level. The coefficients are positively related to the profit level of the turmeric marketers.

The coefficient of education was significant at 1% and positively related to the performance of turmeric marketers. This shows that an increased educational level attended by the turmeric marketer will increase the performance level of the marketers. This is in line with a priori expectations. The acquired education enables the marketers to manage the market techniques, leading to efficient performance. The finding agrees with results of Apata *et al.* (2009) Who reported that better education enables households to access and conceptualize information on improved farming methods and other related issues to enhance their welfare. The coefficient of extension visits was significant and positively related to the performance of marketers. This implies the more the extension visits to the marketers, the better the marketer's performance. This is in line with the a *priori* expectation. The more the extension visits, the better the marketer, as the marketers are being directed, helped to identify their needs, problems, and opportunities that will help for higher performance in marketing.

The coefficient of membership of the cooperative was significant at 1% and positively related to the performance of the marketers. This could be that as a cooperative member, the union is secure and can make a decision that will stand for better members' performance. It may also be that the members know the market techniques and market strategies and, therefore, perform better than their counterparts who are not members. Similarly, the coefficient of marketers' income was significant and positively related to the performance of turmeric marketers. This implies that an increase in the income of the marketers will lead to a rise in their investment. It will encourage their investment in marketing and create more money for saving. The finding agrees with the results of Anyanwu *et al.* (2016) who reported that the increase in the income of the respondents would increase their expenditure on value addition. This finding aligns with a*priori* expectation; an increase in income will enable the respondents to purchase the requisite inputs for enhanced output and income.

The coefficient of transportation was significant at 1% and negatively related to the performance of marketers. This implies that as the cost of transportation increases, the marketing performance decreases. Marketing activities associated with turmeric marketing involve loading, offloading, carry to stores, and the high cost attached will reduce the marketing performance of turmeric marketers. The coefficient of storage cost was significant and negatively related to the performance; it is in line with the a*priori* expectation that much expenses to the marketing will lead to a reduction in performance. The coefficients of distance to the source of credit, transportation cost, storage cost, and purchase price were all significant at a 1.0% probability level and are negatively related to the performance level of the turmeric marketers. The results show that the variables harm the performance level of turmeric marketers. This means that any increase in these variables will lead to a decrease in the performance level of the turmeric marketers. This is in line with *aprior* expectation. The coefficients of age, gender, marketing experience, and household size were insignificant and unrelated to the turmeric marketers' profit level.

CONCLUSION

The study revealed that most turmeric marketers were females and were married. The net return was ₦25,710.00, implying that turmeric marketing is profitable. The education acquired by the marketers enables them to manage the market techniques, leading to efficient performance in turmeric marketing It is therefore recommended that males should be encouraged to market turmeric since it is profitable and a source of livelihood. Awareness campaigns should be made to popularize the crop and its benefits.

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PRIORITIZATION OF DESIRABLE TRAITS ALONG THE YAM VALUE CHAIN: A REVIEW OF INSIGHTS AND OUTCOMES FROM THE RTBFOODS INITIATIVE ON DEMAND-DRIVEN BREEDING IN NIGERIA

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ABSTRACT
The National Root Crops Research Institute (NRCRI) and its partners have been working together to implement gender-inclusive approaches to enhance the effectiveness of breeding. Through the experiences of the crosscutting gender team at NRCRI, this study has documented the successes encountered in this process. The study provides valuable insights and recommendations for future efforts towards achieving gender equality and inclusive development in the field of crop breeding. Prioritizing of desirable traits along the Yam Value Chain in Nigeria to Enhance Demand-led Breeding: Outcomes from the RTBfoods Project refers to a study conducted as part of the RTBfoods project, which aimed to improve the adoption, productivity, and profitability of yam cultivation in Nigeria. The study focused on identifying and prioritizing the most desirable traits in yam varieties, to enhance demand-led breeding efforts. The outcomes of the project provide valuable insights into how targeted breeding efforts can be used to improve the quality and yield of yam crops, and ultimately increase their commercial viability and adoption. One of the key strategies for improving food security, income, and nutrition at the household level, as well as the overall well-being of various value chain actors, is to introduce yam varieties that are tailored to meet the preferences of consumers. By incorporating preferred traits into the product profiles, it is expected that the adoption of these varieties will be widespread. This will result in significant benefits for farmers, traders, and consumers alike, all of whom will enjoy the positive impacts that come with having access to high-quality and nutritious yams. The success stories that highlight the achievements in the RTBfoods project reveal that effective communication and cooperation within the gender cross-cutting team and farmer groups play a crucial role in achieving better results. When gender specialists, food scientists, and breeders work together, they create innovative solutions that help overcome challenges and promote the sharing of information. Such collaborations bring a unique perspective to the table and help in achieving sustainable development goals.
Keywords: *Multidisciplinary team, plant breeding, traits, consumers, RTBfoods Project*

INTRODUCTION
According to the FAO, Nigeria produces about 50 million metric tons of yam annually, followed by Ghana (85.3 million tons), Côte d'Ivoire (77 million tons), and Benin (32 million) (FAO, 2021). The National Root Crops Research Institute (NRCRI) has been developing yams that are suitable for production and use. Yams are a particularly important root and tuber crop in Nigeria, although demand for them is influenced by both their short shelf life and the variety of dishes that households create with them. In Nigeria, yam is widely grown in regions where women contribute more farm labor, managing the use of the crop and adding value to it (Rahman *et al*., 2006). Despite the yam's nutritional importance (Bradbury and Holloway, 1988) and contribution to calorie intake in West Africa (Asiedu and Sartie, 2010), Barlagne *et al*. (2016) highlighted the lack of understanding of consumers' preferences for yam features and product quality. According to Madu *et al*. (2021a), breeding programs have historically prioritized yield and other agronomic traits at the expense of post-harvest and consumer preferences, so there is a knowledge gap regarding preferences for root, tuber, and banana (RTB) crops among various user groups, such as food processors, retailers, and consumers. Additionally, explanations of product characteristics are frequently overly brief and oversimplified, leaving out details on the ideal range of an attribute that users require. Additionally, little to nothing is known about the interactions between gender relations and norms.

The International Institute of Tropical Agriculture (IITA), the National Root Crops Research Institute, Umudike, Nigeria, Ebonyi State University, Abakiliki, Nigeria, two Research Institutes under the Council for Scientific and Industrial Research (CSIR) in Ghana (the Crops Research Institute in Kumasi and the Savanna Agricultural Research Institute in Tamale), the Centre National de Recherche Agronomique (CNRA) in Côte d'Ivoire and l'Université d'Abomey-Calavi (UAC), Dassa, Benin are the institutional actors driving a change in the breeding of yams. In recognition of the increasing popularity of yams in East and Central Africa, the National Crops Resources Research Institute (NACRRI) in Kampala, Uganda also joined the effort. This breeding project became a multidisciplinary effort involving breeders, geneticists, food scientists, agronomists, social scientists and end users. It is worth noting that research organizations outside the sub-region also played major roles in the project, including the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) in Montpellier, France; the Iwate Biotechnology Research Center (IBRC) in Japan; the James Hutton Institute (JHI) in the UK; Japan International Research Center for Agricultural Sciences (JIRCAS) in Japan; and the Boyce Thompson Institute for Plant Research (BTI) at Cornell University in the USA.

METHODS AND APPROACHES

The team in this particular study followed the RTBfoods method for integrating gender into product profiles for boiled and pounded yam from 2018 to 2022 (Forsythe *et al*., 2021). This method consists of four steps that help to identify and prioritize the food product profile. The first step is to establish the scope of the study and identify the gaps in research, i.e., the state of knowledge (SOK) for boiled and pounded yam (Madu *et al*., 2019; Otegbayo, 2018). The second step is to elicit a set of ranked quality characteristics from users who play different roles in the value chain and gain an in-depth social context on boiled (Madu *et al*., 2021a) and pounded yam (Otegbayo *et al*., 2021). Experienced processors are consulted in the third step to identify more quality characteristics of boiled and pounded yam, as they possess crucial knowledge about the market and consumers' expectations. In this method, the processors, who are predominantly women, prepare the boiled and pounded yam in their local fashion (Madu *et al*., 2021b). In the fourth step, questionnaires are developed based on the results of Step 3 to collect robust data on preferences for the final product among a diverse set of consumers (Otegbayo *et al*., 2020; Madu *et al*., 2021c; Madu *et al*., 2021d). The results from all the steps are then triangulated to prioritize the food product profile. This integrated method enables a deep understanding of the quality characteristics, translating tacit knowledge into data that can be further investigated by scientists. The team also used laboratory-based sensory evaluation to corroborate the results from Steps 3 and 4, using scientific and industry-standard methods to support breeding and product development work. Overall, this method provides a comprehensive approach to integrating gender perspectives into product development, ensuring that the final product meets the diverse needs and preferences of all consumers.

DISCUSSION

The RTBfoods project was instrumental in bringing together a multidisciplinary team of experts from various fields including breeders, agronomists, pathologists, food scientists, socio-economists, and gender specialists. The project aimed to bridge the gap between understanding consumer preferences and packaging that knowledge into a breeding framework that could increase the efficacy of selection and adoption of improved root and tuber crop (RTC) varieties in Africa. The project commenced in 2017 and focused on four food product profiles, namely boiled yam, pounded yam, fufu, and gari. The multidisciplinary team worked together to achieve the project's objectives, and their efforts proved to be highly successful. As a result, the team evolved into a gender team, which included gender specialists, socio-economists, food scientists, and breeders. The team recognized the importance of gender considerations in demand-driven and targeted breeding for breeders, as the data on gender differences and dynamics were highly convincing. Overall, the project was a great success and helped to bring together experts from multiple fields to achieve a common goal. The team's focus on gender considerations has proved to be crucial in driving demand-driven and targeted breeding for breeders, and will likely have a lasting impact on the field for years to come.

The outcome of the team's baseline survey using social survey research, e.g., focus group discussions, key informant interviews, individual interviews and market interviews was documented. We documented key priority traits desired by the farmers, consumers and marketers and found that different sections of the country have their similarities and differences (Madu *et al*., 2020; Otegbayo *et al*., 2020). Also, quality traits (Study of trait preferences) were found to vary by region; in the west of Nigeria, a food called *amala* is made from dried yam, ground into flour. Drying the yams makes them dark, so the colour of the tubers does not matter. But in South-East Nigeria, white tubers were important for making pounded and boiled yams. These traits were also emphasized within the triangulation and G+ tools. The product chain includes production, usually men assisted by women and youths on male-owned farms. Adult men usually harvest and transport the yams, while men and women sell them. Marketers and consumers include hoteliers, households, food vendors, schools, hospitals etc. (Madu *et al*., 2018). In the South-East and South-West regions consumers have preferences for certain yam traits at various stages: 1) agronomic and postharvest, 2) processing, and 3) prepared foods (Otegbayo *et al*., 2021). Men, who produce yams, emphasize yield and colour, while women processers pay attention to texture, taste, ease of peeling, aroma, mealiness, poundability, and color.

We set up our research so that each member of the gender team focused on their area of expertise. Farmers were divided into gender groups for FGDs by some researchers (gender specialists, extension specialists). Other researchers conducted individual, key informant, and market interviews, including economists, food scientists, enumerators, etc. For instance, in Ebonyi State, different Igbo dialects presented a communication challenge for our enumerators, but this was resolved by the guide interpreter that we used for the studies. The farmers were able to be understood by tour guides and extension specialists who were fluent in the regional dialects.

Lessons learned and outcomes

The approach used in the breeding protocol involved a combination of methods that were effective in promoting a better understanding of the process. The bottom-top approach was used to develop demand-led, gender-intentional product profiles. The use of pair-wising, hedonic scales, scores, percentages, and ranks was instrumental in rating the importance of choice traits. Additionally, the G+ tool was employed to help trade off traits. In future yam studies, economic values will be assigned to traits to prioritize their preferences. This method changes the traditional economic approach to ranking tools, balances economic and non-economic drivers, and quantifies views of participants by gender and social strata. The multidisciplinary approach was employed from the start of breeding to select the traits that end-users prefer and involve these actors in the process. The focus is on breeding for the end-users and facilitating the release and adoption of new varieties. Holistic information from all stakeholders is provided, and women are involved in the different stages, not just cultivation, which is typically dominated by men. High and medium-throughput methods, such as Near-Infrared Spectroscopy (NIRS), were developed and used to save time and money when making breeding decisions. The correlation of consumer-preferred traits with the biophysical properties identified in the lab was used to obtain a threshold for selection. This has already been developed for rapid characterization of the colour and texture of gari-eba.

The RTBfoods project has been successful in achieving its goals, and the success stories that highlight these achievements reveal some valuable insights. One of the most crucial factors that contribute to the success of this project is effective communication and cooperation within the gender cross-cutting team and farmer groups. When gender specialists, food scientists, and breeders work together, they create innovative solutions that help overcome challenges and promote the sharing of information. The collaboration between different groups brings a unique perspective to the table, which helps in achieving sustainable development goals. The success stories of the RTBfoods project demonstrate how such collaborations have led to improved crop yields, reduced crop losses, and better nutrition outcomes. These achievements are a testament to the power of effective communication and cooperation in achieving common objectives. The project is a remarkable example of how diverse groups can work together to achieve sustainable development goals. The project's success stories demonstrate that professionals from different domains, such as gender specialists, food scientists, and breeders, can create innovative solutions by collaborating and sharing information. This project's achievements are a result of effective communication and cooperation among the team members. Their commitment to the shared vision of sustainable and equitable agricultural practices has helped pave the way for more environmentally friendly and socially just food production systems. The project is a testament to the power of collaboration and the potential of interdisciplinary approaches to drive meaningful change.

CONCLUSION

The RTBfoods project aimed to develop a breeding framework for improved root and tuber crop varieties in Africa, focusing on four food product profiles: boiled yam, pounded yam, fufu, and gari. A multidisciplinary team, including breeders, agronomists, pathologists, food scientists, socio-economists, and gender specialists, documented key priority traits and regional preferences. The breeding protocol employed a bottom-top, gender-intentional approach, balancing economic and non-economic drivers. A multidisciplinary approach was used to select preferred traits, involving stakeholders and utilizing high and medium-throughput methods like Near-Infrared Spectroscopy. The project serves as a great example of how different groups can work together to achieve sustainable development goals. The success stories of this project demonstrate that gender specialists, food scientists, and breeders can create innovative solutions by collaborating and sharing information. Through effective communication and cooperation, the RTBfoods project has been able to achieve great results and pave the way for more sustainable and equitable agricultural practices.

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Federal University of Lafia Nasarawa State

"LAFIA"

SUB-THEME 3:

Transforming Women Participation in Agriculture: Challenges and Opportunities

ADOPTION OF CASSAVA VALUE CHAIN AMONG WOMEN CASSAVA FARMERS IN EBONYI STATE

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ABSTRACT
This study analyzed the Adoption of Cassava Value Chain among Women Cassava Farmers in Ebonyi State. Structured questionnaire was administered on 270 respondents selected using multistage random sampling. Descriptive statistics was used to analyse the data. Result collected showed that mean age and cassava farm size of the respondents were 48.54 years and 0.42 hectare respectively. 65.93% of them were married, with 81.11% attaining different levels of formal education. Meanwhile, 54.44% and 46.67% of them obtained information on cassava value addition technologies from Agricultural developmental programme. Cassava value added technologies such as garri ($\bar{X}$ = 4.30), cassava fufu ($\bar{X}$ = 3.66), high quality cassava flour ($\bar{X}$= 3.02), cassava chips ($\bar{X}$ = 3.18) and fermented flour ($\bar{X}$ = 3.01) were adopted by the women farmers. It was recommended that training on cassava value added technologies and provision of credit facilities to women cassava farmers should be intensified. This will enable them adopt value added technologies and improve their welfare.
Keywords: *Adoption, cassava, value added technologies, women farmers.*

INTRODUCTION

Cassava (*Manihot* species) is the most popular and widely cultivated crop in Nigeria in terms of area planted and total number of farmers involved in its cultivation (Ebewore and Okedo-Okojie, 2016; Oyelere, 2020). Nigeria produces over 54 million metric tons (MT) of cassava per annum (FAOSTAT, 2021), making her the highest cassava producer in the world, producing about a third more than Brazil and almost double the production capacity of Thailand and Indonesia. Cassava value chain is the act of adding value to a product with the view of improving certain characteristics (FAO, 2011). Cassava value chain helps to reduce bulk and improve product quality. It facilitates transportation and marketing, reduce cyanide content and improve palatability of the product (Odebode, 2008).The need to add value to cassava is made more imperative by the global demand for cassava and its products, which competes with local demand (Agbarevo and Okeke-Sam, 2015)

RESEARCH METHODOLOGY

Area of Study

The study was carried out in Ebonyi State of Nigeria. The State is located between latitude $5^{0}41'$ and $6^{0}50'$N of Equator and Longitude $5^{0}25'$ and $7^{0}30$E of Greenwich Meridian. Its rainfall ranges from 1500 mm-2500 mm per annum, temperature of 28-48^{0}C and average relative humidity of 75%. It is bounded in the North by Benue State, South by Abia State, in the East by Cross River State and in the West by Enugu State. Ebonyi State is made up of three Agricultural zones namely North, Central and South. The North agricultural zone consists of four local government areas: Abakaliki, Ebonyi, Izzi and Ohaukwu. The Central Agricultural zone has four Local Government Areas: Ezza North, Ezza South, Ikwo and Ishielu, while the South agricultural zone has five local government areas: Afikpo North, Afikpo South, Ivo, Ohaozara and Onicha. Among the crops planted in the area are cassava, yam, sweet potato, rice, maize and tomato.

Sampling Technique

The population for this study consists of all women cassava farmers in the study area who had benefitted from training on cassava value addition organized by government and/or private agencies. Multistage random sampling technique was used to select respondents for the study. In the first stage, two agricultural zones were randomly selected from the three agricultural zones that make up the State. In stage two, three extension blocks were selected from each of the selected zones. This gave six extension blocks. Stage three involved random selection of three extension circles from each of the blocks to give eighteen extension circles. List of women cassava farmers who had benefitted from cassava value addition trainings in each selected circle was formulated with the help of extension agents. The list served as the sampling frame from which 15 women cassava farmers were randomly selected from each of the eighteen extension circles to give a sample size of 270 women cassava farmers who served as respondents for the study.

Method of Data Collection

Primary data were used and were collected from the women farmers on socio-economic characteristics such as age, household size, marital status, education level, cassava farm size, quantity of cassava produced, membership to cooperative societies, access to credit and access to extension agents. Also, data on sources of information on cassava value addition technologies, types of cassava value addition technologies practiced, level of adoption of cassava value addition technologies and welfare indices to adoption of cassava value addition technologies were collected.

Method of Data Analysis

Descriptive and inferential statistics were used in analyzing the data on socio-economic characteristics of the respondents and to identify sources of information on cassava value added technologies were analyzed using descriptive statistics. Level of adoption of cassava value added technologies was determined using adoption scale analysis. It was achieved with the aid of a 7-point Likert type scale graded thus; unaware = 0, Aware = 1, interest = 2, evaluation= 3 trial = 4, accept = 5 and satisfaction = 6. In accordance with Okoye *et al*., (2009) the mean adoption level was determined as follows:

$\bar{X_s} = \Sigma x/n$ ……………… (1)

Mean score was computed by multiplying the frequency of each response pattern with its appropriate nominal value and dividing same with the number of respondents to the terms. This is summarized with the equation below.

$\bar{X_s} = \Sigma fn/nr$ ………………. (2)

Where: $\bar{X}$ = Mean score; $\sum$ = summation; F = frequency; n = Likert nominal value;
nr = Number of respondents. $\bar{X} = (0+1+2+3+4+5+6)/7 = 21/7 = 3.0$

Decision Rule: Below 1.0 = Unaware stage; 1.0 - 1.49 = Awareness stage; 1.50 - 1.99 = Interest stage; 2.0 - 2.49 = Evaluation stage; 2.50 - 2.99 = Trial stage; 3.0 and Above = Adoption of cassava value added technology

RESULTS AND DISCUSSION

Socio-Economic Characteristics of Respondents

The distribution of the respondents according to their socio-economic characteristics is shown in Table 1. It shows that 33.33% of the women cassava farmers were within the age range of 40 - 49 years. The mean age of the women cassava farmers was 48.54 years. Drawing from Pandey and De (2015) classification of farmers by age (< 36 years = young farmers; 36 – 50 years = middle aged farmers; > 50 years = old farmers) the mean age of the women cassava farmers indicates that they were mostly middle aged and still energetic and capable of withstanding any stress associated with practice of adding value to cassava. The Table also shows that 65.93% of the farmers were married, while 17.78% were single. This shows that the married class dominated among the women farmers who received training. The result further indicates that 47.41% of the respondents had secondary education, 23.33% had primary education, 6.67% had tertiary education, while 22.59% had no formal education. Ebewore and Okedo-Okojie (2016) asserted that widespread illiteracy among farmers hinders understanding of information at their disposal. Therefore, educated farmers are expected to be more receptive to technologies, while farmers with low level of education or without education would be less receptive to utilization of new technologies (Okoye, 2009).

Table 1: Distribution of the respondents according to socio-economic characteristics

Variables	Frequency	Percentage (%)	Mean
Age (years)			
20-29	27	10.00	
30-39	51	18.89	
40-49	90	33.33	48.54
50-59	57	21.11	
60-69	27	10.00	
70 and above	18	6.67	
Marital Status			
Single	48	17.78	
Married	178	65.93	
Widow	42	15.56	
Divorced/separated	2	0.83	
Education Level			
No formal education	51	18.89	
Primary school education	63	23.33	
Secondary School education	138	51.11	

Tertiary school education	18	6.67	
Size of Cassava Farm (hectare)			
0.1 - 0.5	153	56.67	0.42
0.6 - 1.0	98	36.30	
>1.0	19	7.03	
Membership of Cooperatives			
Yes	132	48.89	
No	138	51.11	
Credit Access			
Yes	120	44.44	
No	150	55.56	

Source: Field survey data, 2022

Additionally, the mean size of the respondent's cassava farm was 0.42 hectares, indicating that the respondents were majorly small-scale farmers. The few respondents (7.03%) who allocated more than 1.0 hectare to cassava production may be the ones that produce cassava for commercial purposes. About 48.89% of the respondents belonged to cooperative societies, while, 51.11% of them did not belong to cooperative societies. Belonging to cooperative societies enhances participation in an intervention programme, as well as access to information on improved technologies (Odoemenam, 2007). Farmers communicate most frequently and effectively with those who are familiar to them and are more likely to obtain information from and be influenced in their adoption decision by other farmers. The table reveals that 55.56% of the respondents had no access to credit. Access to credit makes it possible for farmers to purchase inputs including equipment used in cassava value addition and this helps to increase quantity of cassava to which value is added. The result is in support of earlier finding by Awotide *et al.* (2013) that many farmers in Nigeria had no access to credit facilities.

Sources of Information on level of Adoption of Cassava Value Chain

The distribution of the respondents according to sources of information on cassava value added technologies is shown in Table 2. The table shows that 54.44% of the women cassava farmers obtained information and training on cassava value chain from extension agents domiciled within Agricultural Development Programme (ADP), while 46.67% of them received information on cassava value added innovations from private farms. The greater number of respondents that obtained information and training on cassava value chain from ADP and private farms confirms their statutory mandate and contribution towards improving welfare of rural farmers through training and extension programme. Internet as a source of information has the least number of respondents (5.56%) indicates that the level of ICTs use as a means of sourcing agricultural information among rural women in the study area was still low and lends credence to Osondu and Ijioma (2015) assertion that level of use of ICTs among women farmers in Nigeria was low.

Table 2: Distribution of the respondents according to source of information on level of adoption of Cassava Value Chain

Extension Access	* Frequency	Percentage
Agricultural Development Programme (ADP)	147	54.44
Tv/radio	37	13.70
Internet	15	5.56
Farmers/women association	85	31.48
Friends	49	18.15
Private Farms	126	46.67

Source: *Field survey data, 2022*

***** Multiple responses recorded: n = 270

Level of Adoption of Cassava Value Chain by women cassava farmers

The level of adoption of cassava value added technologies among the women cassava farmers was investigated and the result presented in Table 3. Table 3 shows that garri ($\bar{X}$= 4.30), cassava fufu ($\bar{X}$ = 3.66), high quality cassava flour ($\bar{X}$ = 3.02) cassava chips ($\bar{X}$= 3.18) and fermented flour ($\bar{X}$ = 3.01) all had mean score values that are greater than the Likert critical score of 3.0, implying that these cassava value added technologies were adopted by the women farmers. Adoption of these post-harvest value added technologies is expected to increase shelf life, income and food security of the rural poor (Carolyn, *et al.*, 2015). The table also shows that the grand mean score ($\bar{X}$= 2.22) for adoption of cassava value added technologies by the women farmers was low, suggesting that there were still gaps in adoption of most of the other cassava value added technologies extended to the women farmers. This implies that ample opportunities exist to increase level of adoption of cassava value chain among women farmers by exposing them to more information and training.

Table 3: Level of Adoption of Cassava value chain by the women cassava farmers

Cassava Value Added Technologies	Unaware (0)	Aware (1)	Interest (2)	Evaluation (3)	Trial (4)	Accept (5)	satisfaction (6)	Total	Mean Score
Cassava fufu	0(0)	60(60)	27(54)	30(90)	42(168)	51(255)	60 (360)	987	3.66
HQCF	72 (0)	24(24)	24(48)	15(45)	33(132)	45(225)	57 (342)	816	3.02
Garri	0(0)	24(24)	27(54)	33(99)	30(120)	72 (360)	84 (504)	1161	4.30
Cassava strip	99(0)	45(45)	36(72)	12(36)	15(60)	33(165)	30 (180)	558	2.07
Cassava starch	102(0)	33(33)	12(24)	18(36)	27(108)	39(195)	39 (234)	648	2.40
Cassava bread	132(0)	45(45)	18(36)	9(18)	21(84)	24(120)	21 (126)	438	1.62
Cassava cake	90(0)	48(48)	30(60)	18(54)	6(24)	36(180)	27 (162)	528	1.96
Cassava chin chin	159(0)	45(45)	21(42)	3(9)	15(60)	18(90)	9 (54)	300	1.11
Cassava croquette	177(0)	39(39)	36(72)	0(0)	3(12)	15(45)	6 (36)	204	0.76
Fermented flour	69(0)	30(30)	18(36)	18(54)	30(120)	57(285)	48 (288)	813	3.01
Cassava doughnut	171(0)	39(39)	15(30)	6(18)	18(72)	6(30)	15 (90)	279	1.03
Cassava chips	24(0)	69(69)	24(48)	24(72)	30(120)	45(225)	54 (324)	858	3.18
Cassava pellet	207(0)	24(24)	6(12)	3(9)	9(36)	9(45)	12 (72)	198	0.73
Grand mean									2.22

***Source:** Field survey data,*

CONCLUSIONS

Level of Adoption of Cassava value chain by the women cassava farmers improved, though some gaps still exist in the study. Significantly as a result of adoption of Cassava Value Chain among Women Cassava Farmers. Factors such as age, education level, extension contact, processing cost, annual income, group membership, access to credit and quantity of cassava produced significantly influenced the women farmers level of adoption of Cassava value chain.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations suffice:

i. level of Adoption of cassava value chain impacted positively on women cassava farmers welfare by exposing them to more information and training.

. Government at all levels should promote policies and implement actions that will enhance access of women cassava farmers to trainings on cassava value chain. To this end, government should take measures that will enhance extension service delivery to women farmers. This will enable women farmers earn more income and improve their welfare.

ii. Policy makers should come up with loan packages intended specifically for people interested in adding value to agricultural products through their cooperative societies. Mechanisms should also be put in place to monitor how the funds borrowed are used. This will reduce the financial encumbrances associated with adoption of cassava value chain and increase adoption rate.

iii. Women cassava farmers should be encouraged to form and belong to cooperative societies. This will avail them access to various opportunities such as training, credit facilities, inputs and markets.

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SOCIO-ECONOMIC CHARACTERISTICS ON ADOPTION OF CASSAVA VALUE ADDED TECHNOLOGIES ON WOMEN CASSAVA FARMER'S WELFARE IN EBONYI STATE.

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ABSTRACT
This study analyzed the effect of Socio-economic characteristics on adoption of cassava value added technologies on welfare of women cassava farmers in Ebonyi State, Nigeria. Structured questionnaire was administered on 270 respondents selected using multistage random sampling. Descriptive statistics, and adoption scale analysis, were used to analyse the data. Result collected showed that mean age and cassava farm size of the respondents were 48.54 years and 0.42 hectare respectively. 65.93% of them were married, with 81.11% attaining different levels of formal education. Meanwhile, 54.44% and 46.67% of them obtained information on cassava value addition technologies from Agricultural developmental programme. Cassava value added technologies such as garri ($\bar{X}$ = 4.30), cassava fufu ($\bar{X}$ = 3.66), high quality cassava flour ($\bar{X}$= 3.02), cassava chips ($\bar{X}$ = 3.18) and fermented flour ($\bar{X}$ = 3.01) were adopted by the women farmers. It was recommended that training on cassava value added technologies and provision of credit facilities to women cassava farmers should be intensified. This will enable them adopt value added technologies and improve their welfare.
Keywords:** Adoption, cassava, value added technologies, women farmers.**

INTRODUCTION
Cassava (*Manihot* species) is the most popular and widely cultivated crop in Nigeria in terms of area planted and total number of farmers involved in its cultivation (Ebewore and Okedo-Okojie, 2016; Oyelere, 2020). Nigeria produces over 54 million metric tons (MT) of cassava per annum (FAOSTAT, 2021), making her the highest cassava producer in the world, producing about a third more than Brazil and almost double the production capacity of Thailand and Indonesia.

Value added technologies are the processes of changing or transforming a product from its original state to a more valuable state (Mmasa, 2013). It is the act of adding value to a product with the view of improving certain characteristics (FAO, 2011). Cassava value added technologies helps to reduce bulk and improve product quality. It facilitates transportation and marketing, reduce cyanide content and improve palatability of the product (Odebode, 2008).The need to add value to cassava is made more imperative by the global demand for cassava and its products, which competes with local demand (Agbarevo and Okeke-Sam, 2015).

RESEARCH METHODOLOGY
Area of Study
The study was carried out in Ebonyi State of Nigeria. The State is located between latitude $5^0$41' and $6^0$50'N of Equator and Longitude $5^0$25' and $7^0$30E of Greenwich Meridian. Its rainfall ranges from 1500 mm-2500 mm per annum, temperature of 28-48^{0}C and average relative humidity of 75%. It is bounded in the North by Benue State, South by Abia State, in the East by Cross River State and in the West by Enugu State. Ebonyi State is made up of three Agricultural zones namely North, Central and South. The North agricultural zone consists of four local government areas: Abakaliki, Ebonyi, Izzi and Ohaukwu. The Central Agricultural zone has four Local Government Areas: Ezza North, Ezza South, Ikwo and Ishielu, while the South agricultural zone has five local government areas: Afikpo North, Afikpo South, Ivo, Ohaozara and Onicha. Among the crops planted in the area are cassava, yam, sweet potato, rice, maize and tomato. Multistage random sampling technique was used to select respondents for the study. In the first stage, two agricultural zones were randomly selected from the three agricultural zones that make up the State. In stage two, three extension blocks were selected from each of the selected zones. This gave six extension blocks. Stage three involved random selection of three extension circles from each of the blocks to give eighteen extension circles. List of women cassava farmers who had benefitted

from cassava value addition trainings in each selected circle was formulated with the help of extension agents. The list served as the sampling frame from which 15 women cassava farmers were randomly selected from each of the eighteen extension circles to give a sample size of 270 women cassava farmers who served as respondents for the study. Primary data was collected from the women farmers on socio-economic characteristics such as age, household size, marital status, education level, cassava farm size, quantity of cassava produced, membership to cooperative societies, access to credit and access to extension agents. Also, data on sources of information on cassava value addition technologies, types of cassava value addition technologies practiced, level of adoption of cassava value addition technologies and welfare indices to adoption of cassava value addition technologies were collected.

Descriptive and inferential statistics were used in analyzing the data on socio-economic characteristics of the respondents and to identify sources of information on cassava value added technologies were analyzed using descriptive statistics. Level of adoption of cassava value added technologies was determined using adoption scale analysis. It was achieved with the aid of a 7-point Likert type scale graded thus; unaware = 0, Aware = 1, interest = 2, evaluation= 3 trial = 4, accept = 5 and satisfaction = 6. In accordance with Okoye *et al*., (2009) the mean adoption level was determined as follows:

$\overline{(X\_s)}=\Sigma x/n$ ……………… (1)

Mean score was computed by multiplying the frequency of each response pattern with its appropriate nominal value and dividing same with the number of respondents to the terms. This is summarized with the equation below.

$\overline{(X\_s)}=\Sigma fn/nr$ ………………. (2)

Where: $\bar{X}$ = Mean score; $\sum$ = summation; F = frequency; n = Likert nominal value;
nr = Number of respondents. $\bar{X}$ = (0+1+2+3+4+5+6)/7=21/7 = 3.0

Decision Rule: Below 1.0 = Unaware stage; 1.0 - 1.49 = Awareness stage; 1.50 - 1.99 = Interest stage; 2.0 - 2.49 = Evaluation stage; 2.50 - 2.99 = Trial stage; 3.0 and above = Adoption of cassava value added technology

RESULTS AND DISCUSSION

Socio-Economic Characteristics of Respondents

The results in Table 1revead that 33.33% of the women cassava farmers were within the age range of 40 - 49 years. The mean age of the women cassava farmers was 48.54 years. Drawing from Pandey and De (2015) classification of farmers by age (< 36 years = young farmers; 36 – 50 years = middle aged farmers; > 50 years = old farmers) the mean age of the women cassava farmers indicates that they were mostly middle aged and still energetic and capable of withstanding any stress associated with practice of adding value to cassava. The table also shows that 65.93% of the farmers were married, while 17.78% were single. This shows that the married class dominated among the women farmers who received training. The result further indicates that 47.41% of the respondents had secondary education, 23.33% had primary education, 6.67% had tertiary education, while 22.59% had no formal education. Ebewore and Okedo-Okojie (2016) asserted that widespread illiteracy among farmers hinders understanding of information at their disposal. Therefore, educated farmers are expected to be more receptive to technologies, while farmers with low level of education or without education would be less receptive to utilization of new technologies (Okoye, 2009).

Table 1: Distribution of the respondents according to socio-economic characteristics

Variables	Frequency	Percentage (%)	Mean
Age (years)			
20-29	27	10.00	
30-39	51	18.89	
40-49	90	33.33	48.54
50-59	57	21.11	
60-69	27	10.00	
70 and above	18	6.67	
Marital Status			
Single	48	17.78	
Married	178	65.93	
Widow	42	15.56	
Divorced/separated	2	0.83	
Education Level			
No formal education	51	18.89	
Primary school education	63	23.33	
Secondary School education	138	51.11	
Tertiary school education	18	6.67	
Size of Cassava Farm (hectare)			
0.1 - 0.5	153	56.67	0.42
0.6 - 1.0	98	36.30	

>1.0	19	7.03
Membership of Cooperatives		
Yes	132	48.89
No	138	51.11
Credit Access		
Yes	120	44.44
No	150	55.56

Source: Field survey data, 2022

Additionally, the mean size of the respondent's cassava farm was 0.42 hectares, indicating that the respondents were majorly small-scale farmers. The few respondents (7.03%) who allocated more than 1.0 hectare to cassava production may be the ones that produce cassava for commercial purposes. About 48.89% of the respondents belonged to cooperative societies, while, 51.11% of them did not belong to cooperative societies. Belonging to cooperative societies enhances participation in an intervention programme, as well as access to information on improved technologies (Odoemenam, 2007). Farmers communicate most frequently and effectively with those who are familiar to them and are more likely to obtain information from and be influenced in their adoption decision by other farmers. The table reveals that 55.56% of the respondents had no access to credit. Access to credit makes it possible for farmers to purchase inputs including equipment used in cassava value addition and this helps to increase quantity of cassava to which value is added. The result is in support of earlier finding by Awotide *et al.* (2013) that many farmers in Nigeria had no access to credit facilities.

Sources of Information on Cassava Value Added Technologies

The distribution of the respondents according to sources of information on cassava value added technologies is shown in Table 2. The table shows that 54.44% of the women cassava farmers obtained information and training on cassava value addition technologies from extension agents domiciled within Agricultural Development Programme (ADP), while 46.67% of them received information on cassava value added innovations from private farms. The greater number of respondents that obtained information and training on cassava value addition technologies from ADP and private farms confirms their statutory mandate and contribution towards improving welfare of rural farmers through training and extension programme. Internet as a source of information to the least number of respondents (5.56%) indicates that the level of use of ICTs as a means of sourcing agricultural information among rural women in the study area was still low and lends credence to Osondu and Ijioma (2015) assertion that level of use of ICTs among women farmers in Nigeria was low.

Table 2: Distribution of the respondents according to source of information on cassava value addition technologies

Extension Access	* Frequency	Percentage
Agricultural Development Programme (ADP)	147	54.44
Tv/radio	37	13.70
Internet	15	5.56
Farmers/women association	85	31.48
Friends	49	18.15
Private Farms	126	46.67

Source: *Field survey data, 2022*

***** Multiple responses recorded: n = 270

Table 3: Level of adoption of cassava value added technologies by the women cassava farmers

Cassava Value Added Technologies	Unaware (0)	Aware (1)	Interest (2)	Evaluation (3)	Trial (4)	Accept (5)	satisfaction (6)	Total	Mean Score
Cassava fufu	0(0)	60(60)	27(54)	30(90)	42(168)	51(255)	60 (360)	987	3.66
HQCF	72 (0)	24(24)	24(48)	15(45)	33(132)	45(225)	57 (342)	816	3.02
Garri	0(0)	24(24)	27(54)	33(99)	30(120)	72 (360)	84 (504)	1161	4.30
Cassava strip	99(0)	45(45)	36(72)	12(36)	15(60)	33(165)	30 (180)	558	2.07

Cassava starch	102(0)	33(33)	12(24)	18(36)	27(108)	39(195)	39 (234)	648	2.40
Cassava bread	132(0)	45(45)	18(36)	9(18)	21(84)	24(120)	21 (126)	438	1.62
Cassava cake	90(0)	48(48)	30(60)	18(54)	6(24)	36(180)	27 (162)	528	1.96
Cassava chin chin	159(0)	45(45)	21(42)	3(9)	15(60)	18(90)	9 (54)	300	1.11
Cassava croquette	177(0)	39(39)	36(72)	0(0)	3(12)	15(45)	6 (36)	204	0.76
Fermented flour	69(0)	30(30)	18(36)	18(54)	30(120)	57(285)	48 (288)	813	3.01
Cassava doughnut	171(0)	39(39)	15(30)	6(18)	18(72)	6(30)	15 (90)	279	1.03
Cassava chips	24(0)	69(69)	24(48)	24(72)	30(120)	45(225)	54 (324)	858	3.18
Cassava pellet	207(0)	24(24)	6(12)	3(9)	9(36)	9(45)	12 (72)	198	0.73
Grand mean									2.22

Source: *Field survey data, 2022* Figures in parenthesis are Likert nominal score Decision Rule: > 1.0 = unaware; 1.0-1.49 = aware; 1.50-1.99 = interest; 2.0-2.49 = evaluation; 2.50-2.99 = trial; 3.0 and above = adopted

Level of Adoption of Cassava Value Added Technologies by Women Cassava Farmers

The level of adoption of cassava value added technologies among the women cassava farmers was investigated and the result presented in Table 3. Table 3 shows that garri ($\bar{X}$= 4.30), cassava fufu ($\bar{X}$ = 3.66), high quality cassava flour ($\bar{X}$ = 3.02) cassava chips ($\bar{X}$= 3.18) and fermented flour ($\bar{X}$ = 3.01) all had mean score values that are greater than the Likert critical score of 3.0, implying that these cassava value added technologies were adopted by the women farmers. Adoption of these post-harvest value added technologies is expected to increase shelf life, income and food security of the rural poor (Carolyn, *et al.*, 2015). The table also shows that the grand mean score ($\bar{X}$= 2.22) for adoption of cassava value added technologies by the women farmers was low, suggesting that there were still gaps in adoption of most of the other cassava value added technologies extended to the women farmers. This implies that ample opportunities exist to increase level of adoption of cassava value added technologies among women farmers by exposing them to more information and training on these technologies.

CONCLUSION

Several cassava value addition technologies had been adopted by the women cassava farmers but adoption gaps of cassava value addition technologies still exist in the study area. The welfare of the women farmers improved significantly as a result of adoption of cassava value added technologies. Factors such as age, education level, extension contact, processing cost, annual income, group membership, access to credit and quantity of cassava produced significantly influenced the women farmers adoption of cassava value added technologies.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

i. Adoption of cassava value added technologies impacted positively on women cassava farmers welfare. There is need for the Government at all levels make policies and implement actions that will enhance access of women cassava farmers to training on cassava value added technologies. To this end, government should take measures that will enhance extension service delivery to women farmers. This will enable women farmers earn more income and improve their welfare. Thus, helping to reduce level of poverty amongst them.

ii. Different cassava processing equipment should be made available to women cassava farmers at subsidized rate. This will increase rate of adoption of cassava value added technologies among women cassava farmers.

iii.Policy makers should come up with loan packages intended specifically for people interested in adding value to agricultural products. Mechanisms should also be put in place to monitor how the funds borrowed are used. This will reduce the financial encumbrances associated with adoption of cassava value added technologies and increase adoption rate.

iv. Women farmers need to be sensitized on the importance and impact of adopting value added innovations. To this end, seminars on adoption of value-added innovations should be held in designated venues in all rural communities of the study area. Attempts should be made to motivate women farmers to attend in mass.

v.Women cassava farmers should be encouraged to form and belong to cooperative societies. This will avail them access to various opportunities such as training, credit facilities, inputs and markets.

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RURAL WOMEN PARTICIPATION IN FARMERS' LOCAL ORGANIZATIONS: A PARADIGM SHIFT TO IMPROVING THEIR LIVELIHOOD STATUS IN EDO AND DELTA STATES, NIGERIA

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ABSTRACT
The role of women in meeting family needs and improving on their livelihood status can be achieved through their participation in different organizations whose activities are majorly farm related. However, women's level of participation is influenced by their attitude and some other factors. The study examined rural women participation in farmers' local organizations: A paradigm shift to improving their livelihood status in Edo and Delta States, Nigeria. The sample size of 295 respondents was drawn using the multi-stage sampling technique. Descriptive statistics was used to analyze the objectives of the study while inferential statistics was used to analyze the hypothesis. Results showed that respondents showed favourable attitudes of the farmers which have improved the livelihood status of the respondents. Prevalence of corruption and dishonesty of leaders (mean = 4.13), membership poor response to loan repayment (mean = 4.08) and lack of government assistance (mean = 4.08) were some of the challenges limiting the farmers from participating in FLOs. Based on results, the study recommended that there is need for the leaders of the FLOs to keep clean and transparent practices that can help to instill confidence amongst the people so that they can be encouraged to improve in their level of participation.
Keywords: *Rural women attitude, participation, farmers' local organizations, livelihood status, farmers' income, production level*

INTRODUCTION
Nigerian women have played significant role in the practice and development of agriculture. They actually constitute a large group with diversity in culture and class and are also bound by common issues and experiences which they encounter in different stages of their lives (Izekor and Ilavbarhe, 2021). Izekor and Ilavbarhe (2021) stated that 60 – 80% of the food produced and marketed are carried out by women. This assertion underscores women's essential contributions to the agricultural and rural economies both to the developing nations in particular and the rural economies in general. Nnadi *et al.* (2021) stated that women, within their abode work round the clock, from dawn to dusk and that they do well in getting themselves involved in different tasks within the farm environment with a particular purpose of ensuring that they meet up with their family needs. Okwuokenye *et al.* (2023) opined that the role of women in this regard (meeting family needs) and improving on their livelihood status is achieved through their participation in different organizations like Community Agricultural Workers, Model Farmers, Farmers Local Organizations, etc. whose activities are majorly farm related. The women's level of participation is however influenced by their attitude and some other factors. Against this background, this study sought to: determine the attitude of the rural women farmers towards participating in farm local organizations (FLOs), determine the livelihood status of rural women farmers before and during participation in FLOs and identify the challenges limiting the rural women from effectively participating in FLOs.
The hypothesis of the study**:** There is no significant difference between rural women farmers' livelihood status before and during membership of farmers' local organization

METHODOLOGY
Area of Study
The study was carried out in Edo and Delta States. They both belong to the South-South States of Nigeria Edo state was carved out of defunct Bendel State in August 1991. It has 18 local government areas (LGAs) with Benin

City as its capital. Its estimated population size as at 2022 according to NPC (2022) was 4,777,000 people spread over about 19,639.7 square kilometers. Several mineral endowed in the State are quartzite, marble, limestone, lignite, gold. Petroleum is found in Ovia and Orhionmwon areas of the State (Okwuokenye and Akintoye, 2015). Delta State has 25 Local Government Areas with the capital seat at Asaba. The state has a total land area of 17,698 Km^2 and an estimated population of 5,636,100 people as at 2022 (Delta State, Nigeria - Population). It actually occupies a land area of 17,698 Km^2 with most of the land most suitable for agricultural production activities like production of crops, fish and livestock for food and industry and this stands as the predominant occupation of the people (Okwuokenye and Akintoye, 2015).

A multi-stage random sampling technique was adopted in selecting the sample of the study. In the 1st stage, there was purposive selection of the States (Delta and Edo). This was followed by the 2nd stage that has to do with random selection of 2 agricultural zones from each State, thus making it 4 zones that were used for the study. Stage 3 involved the random selection of two (2) LGAs from each agricultural zone, thereby making it a total of 8 LGAs that were randomly selected for the study. In stage 4, there was random selection of three (3) communities from each of the LGAs and this made the communities used to be twenty-four (24). It was from each of these villages that thirteen (13) farmers were randomly selected (stage 5). The researcher ensured that the respondents used were farmers and membership of FLOs in the area of study. The total number of farmers sampled was 312 and from this two-hundred and ninety-five (295) of the instruments that were suitable for analysis was then used for the study.

Data collected were analyzed using descriptive and inferential statistics. Descriptive statistics was used to analyze rural women farmers' livelihood status before and during their participation in FLOs and this was achieved using the livelihood status index (Mohammed *et al.*, 2019). The index involved presenting the list of 38 likely accrued benefits acquired from the extra or difference in production and income since they became members of FLOs. The assets include: tables, chairs, televisions, decoders, radios, water pumps, purchases of land, block made houses, mattresses, sewing machine, cattle, sheep, plough, ox-plough, fine clothing. It is believed that social benefits such as above mentioned, derived from participation in FLOs can improve productivity, encourage knowledge sharing, promote more rural women farmers participation, improved the people's wellbeing, develop and strengthen relationship among the participants, increased income generation activities and promote diversification and can even give room for off-farm business activities.

Livelihood index was obtained using the model as:

$$LSI = \frac{\text{Number of livelihood factors benefited by } i^{th} \text{ respondent}}{\text{Total number of livelihood benefits}} \quad \text{-----------------------------} (1)$$

Where: LSI = Livelihood status index.

The categorization is stated as: ≤ 0.25 = Very low livelihood; 0.26 – 0.49 = Low livelihood; 0.50 – 0.75 = Moderate livelihood and > 0.75 = High livelihood.

Challenges limiting rural women from active participation in farmers local organization were analyzed using a five – point Likert type scale, coded 5, 4, 3, 2 and 1 for Strongly Agree, Agree, Undecided, Disagree and Strongly Disagree respectively. Factors whose value are equal to 3.0 and above were considered as challenging factors to women participation in FLOs. Contrarily, the factors with values less than 3.0 were regarded as non-challenging factors

Inferential statistics involved the use of Binomial test statistics. Binomial test statistics was used to analyze the hypothesis. The statistics was used to determine the significant difference in proportion of respondents' livelihood status before and during their membership in farmers' local organizations (FLOs). The formula for binomial distribution is given as follows:

b(x;n,p) = nCx*px *(1-p) n-x --(2)

Where:

b = binomial probability; x = total number of successes (livelihood status before and during their membership); p = probability of success on an individual trial; n = number of trials

RESULTS AND DISCUSSION

Attitude of rural women farmers towards participating in farm local organizations

Table 1 shows the results on analysis of the attitude of the rural women towards participating in FLOs. It revealed that a larger fraction (87.46%) of the respondents indicated that the farmers attitude towards participation were favourable, while few (12.54%) of them indicated unfavourable attitude towards participation in FLOs activities. Drawing inference, it could be deduced that a good proportion of the farmers developed a positive attitude to themselves and practices in the groups they belong. The favourable attitude exhibited is an indication that the groups they belong are meeting with their needs or purposes of purpose of registering with the group they belong. This result aligns with assertions of Okwuokenye *et al.* (2023) which stated that that rural farmers need are mostly met in their social groups.

Table 1: Categorization of the respondents based on their attitude towards participation in FLOs

Levels	Frequency	Percent
Unfavourable (score: 18 & below)	37	12.54
Favourable (score: >18)	258	87.46
Total	295	100.0

Source: Field survey, 2023

Rural women farmers' livelihood status before and during membership of farmers local organizations

The livelihood status of the rural women farmers is examined and this was ascertained before and during their membership in FLOs. Table 2 revealed that most (50.51%) of the rural women farmers had low livelihood. On the other hand, during the period of their membership with FLOs, most (56.95%) of the rural women farmers livelihood status improved to a high livelihood status level. The result implies that as members of FLOs, they are able to organize thrift activities from where the farmers are able to obtain finance to improve on their farming activities, access to extension agents who make improved agricultural information and technology available to them which helps to improve their farm output, which consequently translates into increased income, welfare and livelihood. . In addition, in most of the FLOs the rural women are members to have outlets for conduction of thrift activities or "osusu" from where the farmers are able to obtain finance to improve on their farming activities. This result was supported by that of Mohammed, et al. (2019) who reported that farmers' livelihood status gets improved when they participate well in community organizations.

Table 2: Respondents livelihood status before and during membership of FLOs. N=295

Livelihood status of rural women farmers	Livelihood class	Before membership of FLOs		During membership of FLOs	
		Freq.	Percentage	Freq.	Percentage
Very low	0.0 – 0.25	102	34.58	22	7.46
Low	0.26 – 0.50	149	50.51	84	28.47
Moderate	0.51 – 0.75	30	10.17	168	56.95
Very high	0.76 – 1.00	14	4.75	21	7.12

Source: Field survey, 2023

Challenges limiting respondents from participating effectively in farmers local organizations

The challenges limiting the rural women farmers' participation in farmers' local organizations (FLOs) is shown in Table 3. The factors are: prevalence of corruption and dishonesty of leaders (mean = 4.13), membership poor response to loan repayment (mean = 4.08), lack of government assistance (mean = 4.08) and presence of political influence (mean = 4.01). They respectively ranked the 1st, 2nd, 2nd, and 4th most serious challenge limiting rural women farmers from effectively participating in FLOs. This result is consistent with the findings of Okwuokenye *et al*. (2023) that identified similar factors constraining farmers' participation in community based extension organizations (CBEOs). The 5th, 6th, 6th and 8th most serious constraints to rural women farmers participation in FLOs are financial challenges (mean = 3.89), poor access to credit and other agricultural inputs (mean = 3.81), poor leadership style of the executives (mean = 3.81) and lack of awareness (mean = 3.76). These results support the findings of Abdullahi *et al*. (2015) that the later mentioned factors constrained the effective beneficiaries' participation in women non-governmental organizations.

Other constraining factors to rural women participation in local organizations include: socio-economic barriers like age, marital status and educational level (mean = 3.73), time and duration of organization's activities (mean = 3.66), cultural and traditional norms and values (mean = 3.60), poor dissemination of meeting days (mean = 3.41) and clashing of organization's meeting days and communal market days (mean = 3.24). Findings of Deekor (2019) confirmed this result as important factors that actually affect rural farmers' participation in community development projects

Table 3: Challenges limiting respondents from participating effectively in farmers local organizations

Challenges to farmers participation	Mean	Standard Dev.	Rank
- Prevalence of corruption and dishonesty of leaders	4.13*	0.58	1st
- Members poor response to loan repayment	4.08*	0.58	2nd
- Lack of government assistance	4.08*	0.61	2nd
- Presence of political influence	4.01*	0.56	4th
- Financial challenges	3.89*	0.61	5th
- Poor access to credit and other agricultural inputs	3.81*	0.66	6th
- Poor leadership style of the executives	3.81*	0.69	6th

- Lack of awareness	3.76*	0.62	8th
- Socio-economic barriers like age, marital status and educational level	3.73*	0.74	9th
- Time and duration of organization's activities	3.66*	0.73	10th
- Cultural and traditional norms and values	3.60*	0.78	11th
- Poor dissemination of meeting days	3.41*	0.81	12th
- Clashing of organization's meeting days and community market days	3.24*	0.88	13th
- Poor flow of communication and information	2.8	0.83	14th
- High monthly dues	2.4	0.78	15th

**Agreed (mean ≥ 3.0)*

Source: Field survey, 2023

Difference between rural women farmers' livelihood status before and during membership of farmers' local organization

The hypothesis of the study was analyzed with Binomial test and the result is presented in Table 3. As revealed in Table 2, a larger fraction (50.51%) of the rural women farmers indicated that their livelihood status was low before becoming members of FLOs. The livelihood status became high after becoming members of FLOs as indicated by majority (56.95%). In a dichotomy consideration (Table 4) majority (56.95%) indicated high livelihood status level, while the other fraction (43.05%) indicated low livelihood status. Statistically, the result was significant at the 1% level of probability. For this reason, the alternative hypothesis (there is significant difference between rural women farmers' livelihood status before and during membership of farmers' local organization) was accepted against the null. The result thus suggests that being members of FLOs, perhaps provides them the opportunity to have access to extension services that link them to improved farm technology and innovations that is sufficient to improve their farm output and income as well as their livelihood. This assertion was supported by Mohammed *et al.* (2019) who stated that participating in community organizations help to improve farmers' productivity, income and standard of living.

Table 4: Difference in rural women farmers' status before and after membership of FLOs

Status level	:y	ɔns	. Level
- Low Status (Status before membership of FLOs)			
- High Status (Status during membership of FLOs)			
Total			

Source: Field survey, 2023

CONCLUSION AND RECOMMENDATIONS

The rural women farmers showed their attitude to participation in FLOs was favourable and so capable to influencing their participation level. This participation in FLOs helped to alleviate the livelihood status of many of the rural women. The participation level would have been higher with more of their livelihood statues improved if not for the several limiting factors that constrained their participation level.

The study thus recommended that:

i. There is need for the leaders of the FLOs to be more transparent in the execution of their groups' activities as this will help to instill confidence amongst the people and encouraging improvement in their level of participation.

ii. The executives need to put in place strong strategies and modalities through which loans given out could be paid back by beneficiaries. This is necessary so that more money can be made available to give to others in need and have them encouraged to participate more, and;

iii. The FLOs need to be free from all political affiliations so that it will not suffer government neglect, should in case the group appear to be on the other side of the government in power.

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FACTORS AFFECTING THE PARTICIPATION OF RURAL WOMEN IN COMMUNITY ORGANIZATION

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ABSTRACT
The study advocates for rural women participation in community organizations: A strategy to increased economic empowerment amongst women in South-South States, Nigeria. The study used 295 respondents drawn through the use of multi-stage random sampling technique. Descriptive and inferential statistics were respectively used to analyse the objectives and hypothesis of the study. Results showed most (45.76%) of them are effective in their groups and are willing to continue their participation in Farmers Local Organizations (FLOs). Financial and material benefits, rural women farmers empowerment and educating the women were some of the factors enabling participation in FLOs. Average income earned before and during rural women participation in their various community groups was ₦213,266.54 and ₦275,810.79 respectively. Impliedly, participation in community groups have resulted to an average increase of ₦62,544.25. The study recommended that there is a need to empower the women beyond all limits through provision of training skills and needed materials so that they can be encouraged to participate in FLOs.
Keywords: *Rural women farmers, farmers local organizations, economic empowerment, farm production, farm income, participation*

INTRODUCTION
The role of women both at local and international level cannot not be overemphasized. Nnadi *et al.* (2021) stated that women make essential contributions to the agricultural and rural economies. Despite the lofty role of women in our society, their importance to food production and rural development is yet to be appreciated. Nnadi *et al.* (2021) stated that the role of rural women in the rural development effort has been less encouraging when compared to their number and strength. Okwuokenye *et al*. (2023) stated that one of the most reliable ways of overcoming challenges limiting women's participation in social groups is their genuine participation in the group they belong and such enables them not only to function well but also meeting up with their expectations. Against this background, the study advocates for rural women participation in community organizations to enable them get empowered so that they can be able to meet up with their numerous roles both at the family and community level. Specifically, this study determines the effectiveness of rural women participation in the local groups they belong, assess the rural women farming income before and during their participation in community groups, determine the women that are willing and those not willing to continue participating in community groups and identify the enabling factors to women's participation in community organizations. Hypothesis of the study: There is no significant difference between rural women farmers that are willing and those not willing to continue participating in farmers local organizations.

METHODOLOGY
Area of Study
The study was carried out in Edo and Delta States of Nigeria.
Edo State is one of the South-South States of Nigeria, having 18 local government areas (LGAs) with Benin City and it was carved out of defunct Bendel State in August 1991. The estimated population size as at 2022 according to NPC (2022) was 4,777,000 people spread over about 19,639.7 square kilometers (Edo State, Nigeria - Population). The main occupation of most of the people is farming and they are also rich in agricultural production. Edo State is blessed with several mineral resources like quartzite, marble, limestone, lignite, gold. Petroleum is found in Ovia and Orhionmwon areas of the State (Okwuokenye and Akintoye, 2015).

Delta State, one of the six States in the South–South geopolitical zone of Nigeria is the remnant of the defunct Bendel State after State creation in 1991. The State has 25 LGAs with Asaba being the capital seat. Its population size as at 2022 was 5,636,100 people spread across 17,698 Km^2 (Delta State, Nigeria - Population). The inhabitants are mostly farmers of crops and livestock. Others are either into oil prospecting or civil service jobs (Okwuokenye and Akintoye, 2015).

Multi-stage random sampling technique was used in gathering the sample of the study. The first, second and third stages respectively had to do with the purposive selection of the Edo and Delta States which were selected due to their contiguous nature, random selection of two (2) agricultural zones from each of the States, thus making it four zones and the random selection of two (2) LGAs from each agricultural zone and this resulted to making a total of eight (8) LGAs selected for the study. Next was the random selection of three (3) communities / villages from each of the LGAs and this made the communities used to be twenty-four (24) (Stage four). It was from each of these villages that thirteen (13) farmers were randomly selected (stage 5). The researcher ensured that the women used for the study were farmers and are members of any farmers organization's that is still functional in their community where they live. The total number of farmers then became three hundred and twelve (312) and they were the ones administered with the question instrument. From the returned instruments, two-hundred and ninety-five (295) of them suitable for analysis provided the primary data of the study.

The study adopted the use of descriptive statistics which was used to analyze the objectives while inferential statistics (Binomial test) was used to analyze the study's hypothesis. Factors enabling participation in groups were analyzed using a five – point Likert type scale, coded 5, 4, 3, 2 and 1 for Strongly Agree, Agree, Undecided, Disagree and Strongly Disagree respectively. The weighted mean score of 3.0 which was obtained as follows: [5 + 4 + 3 + 2 + 1] / 5) was used to determine if the farmers agreed to the enabling factors or not. Factors whose value are equal to 3.0 and above were considered as enabling factors to women participation in community groups. Contrarily, factors with values that are less than 3.0 were regarded as non-enabling factors. Binomial test statistics was used to analyze if there is no significant difference between rural women farmers that are willing and those not willing to continue participating in farmers local organizations. The formula for binomial distribution is given as follows:

B (x;n,p) = nCx*px *(1-p) n-x ; Where:

b = binomial probability; x = total number of successes (livelihood status before and during their membership); p = probability of success on an individual trial; n = number of trials

RESULTS AND DISCUSSION

Effectiveness of rural farmers' participation in community groups

The level of effectiveness of the rural women farmers' participation in the different groups they belonged was determined and the result is shown in Table 1. Level of effectiveness was described as to the extent the participants were meeting up with their respondents in terms of paying their dues, abiding to the group's rules, etc. The result revealed that most (45.76%) of the respondents indicated that they were very effective in their group's activities. Generally, a larger fraction (91.19%) of the respondents indicated that their level of participation was of average level and above. Impliedly, the respondents are effective in their various groups and this perhaps is linked to the functionality and roles played by the groups to their members. This result is in semblance to the assertion of Usman *et al.* (2022) that cooperative societies are planned to cater for varying needs of her members engaged in agricultural activities.

Table 1: Effectiveness of rural women farmers in their groups

Effectiveness level	Frequency	Percentage	Mode
Very effective	62	21.02	
Just effective	135	45.76	
Averagely effective	72	24.41	
Low effective	18	6.10	
Poorly effective	8	2.71	
Total	295	100.00	Just effective

Source: Field survey, 2023

Assessment of rural women farmers' farm income

Table 2 shows the income of the members of the various groups and this was determined by ascertaining their income level before and during membership of the groups they belong. The result showed that, before the respondents' participation, most (31.19%) of the farmers earned between ₦200,001 – ₦300,000 while most (32.20%) of them earned between ₦300,001 – ₦400,000 during their participation in their various community group. The average income earned before and during rural women participation in their various community groups was ₦275,810.79 and ₦213,266.54 respectively. The result implies that participation in groups have resulted to an average increase in participants income of ₦62,544.25. The result implies that rural women participation in community groups has enhanced farming activities of the farmers by bring about increased production and income. The influence of community social groups is confirmed by Usman *et al.* (2022) who identified increase in yield, income, easy access to extension services and encouragement of self-help and cooperation as some of the benefits derived from being members of cooperative societies.

Table 2: Distribution of the assessment of rural women farmers' farm income

Farm income (₦)	Before membership of social group			During membership of social group		
	Frequency	Percentage	Mean	Frequency	Percentage	Mean
≤ 100,000	28	9.49		17	5.76	
100,001 - 200,000	65	22.03		30	10.17	
200,001 - 300,000	92	31.19		71	24.07	
300,001 - 400,000	81	27.46		95	32.20	
400,001 - 500,000	22	7.46		62	21.02	
> 500,001	7	2.37		20	6.78	
Total	295	100.00	₦213,266.54	295	100.00	₦ 275,810.79

Difference before & during membership of FLOs = ₦275,810.79 – ₦213,266.54 = ₦62,544.25
Source: Field survey, 2023

Rural women farmers' willingness to continue participating in farmers local organizations
Results on rural women farmers willingness to continue participating in farmers local organization revealed that most (35.25%) of the respondents' willingness to continue participating was just high (see Table3). The other rural women farmers willingness to continue participating in FLOs was very high (26.10%), average (23.05%), low (11.86%) and poor (3.73%). On general note, a very high fraction (about 84.4%) and a low fraction (15.59%) of them were respectively willing and not willing to continue participating in FLOs. The result implies that most of the farmers are willing to continue participating in rural women farmers organizations. The reason may not be unconnected to the various benefits they are deriving from their high level of participation, which would have eluded them if they were non-participants. Similar results on high level of participation and farmers willingness to participate and continue participating in social group was observed Okwuokenye and Iduseri (2021) and attributed it to its impact on the economic development of the members. Usman *et al.* (2022) finding also agreed with this result on willingness of rural farmers to participate in social groups since they benefit several

T able 3: Categorization of the respondents on their willingness to continue participating in FLOs

Levels of willingness to participate in FLOs	Frequency	Percentage	Mode
Very high	77	26.10	
Just high	104	35.25	
Average	68	23.05	
Low	35	11.86	
Poor	11	3.73	
Total	295	100.00	Just high

Source: Field survey, 2023

Enabling factors of rural women farmers' participation in farmers local organizations.
Table 4 shows the enabling factors encouraging rural women farmers' participation in FLOs. The factors are arranged in the order of the size of their means. The factors are: financial and material benefits (mean = 4.03), empowering women politically and allowing them some level of social exposure (mean = 3.42), educating the women (mean = 3.41) and breaking the barriers of socio-economic issues (mean = 3.32). Other agreed factors include: breaking the barriers of socio-cultural issues (mean = 3.05), leadership status (mean = 3.05), leadership training (mean = 3.05), motivating women by providing them with incentives (mean = 3.02) and issues of organizational change (mean = 3.01). Financial and material benefits was agreed to give the women some kind of economic empowerment that encourages them to participate in groups. The result is supported by Waweru (2015). The issue of empowering women politically will afford them the opportunity to address their confronting issues. Educating the women was agreed because it is seen as a tool that helps to broaden farmers' horizon and reasoning, develop skill and instill confidence in them. Breaking the barriers of socio-economic issues helps the farmers to overcome certain constraints and enhance efficiency and production. Organizational changes involve structural and institutional changes which are needed to promote members active participation. Women empowerment, educating the women, socio-economic factors and organizational changes were all supported by findings of Mutongu (2012) who concurred with these results and assertions. Socio-cultural issues may include factors that have to do with the norms, values, interactions, customs, etc which have to be broken in order to encourage the rural women farmers participate more in their groups. This assertion is in line with that of Asante *et al.* (2017). Leadership status is in line with the fact that those who hold leadership positions associate and participate more

in community organizations. Leadership training is another factor that has enabled people to become more aware of how to pilot the affairs of their group, handle the members, encourage their participation and derive the necessary potential benefits. Leadership status and leadership training was supported by the findings of Derkyi (2021). Motivating women and providing them with incentives is another way of empowering them and it goes a long way in enabling them to participate effectively in their group, get them more interested and carried along in the group they belong.

Table 4: Enabling factors to respondents' participation in farmers local organizations.

Enabling factors encouraging participation in FLOs	Mean	Standard Dev.	Remark
- Financial and material benefits	4.03*	0.56	Agreed
- Empowering women politically and allowing them some level of social exposure	3.42*	0.52	Agreed
- Educating the women	3.41*	0.57	Agreed
- Breaking the barriers of socio-economic issues	3.32*	0.62	Agreed
- Breaking the barriers of socio-cultural issues	3.05*	0.65	Agreed
- Leadership status	3.05*	0.62	Agreed
- Leadership training	3.05*	0.70	Agreed
- Motivating women by providing them with incentives	3.02*	0.77	Agreed
- Issues of organization change	3.01*	0.75	Agreed
- Domestic and family responsibility	2.47	0.78	Disagreed

**Agreed (Mean ≥ 3.0); Source: Field survey, 2023*

Test of difference in rural women farmers' willingness to continue participating in farmers local organizations

The relationship of rural women farmers' willingness to participate in FLOs was analyzed using binomial test and is shown on Table 5. The results revealed that a larger proportion (89.83%) of the respondents were willing to continue participating in farmers local organizations. Result shows that most of the rural women farmers are willing to continue participating in their social groups. Respondents' unwillingness to continue in groups may be traced to unpleasant past experience that perhaps relate to the social groups not meeting their needs. In line with the proportion of rural women farmers that are willing been 89.83% is an indication that the rural women farmers willing to continue participating in FLOs is significantly high. By implication, the groups are meeting up with their responsibilities to members. Against this background, the alternative hypothesis was adopted. This result is in conformity with findings of Okwuokenye and Iduseri (2021) who revealed farmers' willingness to participate in social group and attributed it to economic impact it has on members.

Table 5: Categorization of respondents' willingness to continue participating in FLOs

Categorization of willingness to continue participating in FLOs	Frequency	Proportion	Prob. Level
- Willing to continue participating in FLOs	265	89.83	0.001
- Unwilling to continue participating in FLOs	30	10.17	
Total	295	100.00	

Source: Field survey, 2023

CONCLUSION AND RECOMMENDATIONS

The study advocated and examined rural women farmers in FLOs in South-South States with a focus in Edo and Delta States, Nigeria. It found that most of the rural women are effective in their groups. The average income earned before and during rural women participation in their FLOs was ₦275,810.79 and ₦213,266.54 respectively and this implies that participation in community groups have resulted to an average increase of ₦62,544.25 in income earned by the farmers. Rural women participation in groups has enhanced farming activities of the farmers by bring about increased production and income.

Based on findings, the study recommends that:

There is a need to empower the women beyond all limits through provision of training skills and needed materials just to encourage their participation in FLOs. Also, rural women farmers need to be encouraged to get themselves educated through free or adult education programme so as to enhance their interest and potential need of participating in FLOs.

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ASSESSMENT OF WOMEN EMPOWERMENT STATUSIIN IBARAPA CENTRAL LOCAL GOVERNMENT, OYO STATE, NIGERIA

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ABSTRACT
The study examined the assessment of women empowerment status in Ibarapa Central Local Government Area of Oyo State, Nigeria. Primary data were used for the study. One hundred and twenty women were interviewed using multistage sampling techniques. The socioeconomic characteristics of the women revealed that the mean age was 36 years old. The mean household size was three About 90.83% of the women were married, 55.83% of the respondents had secondary school education, the average number of children was four. Primary occupation of the respondents revealed that 45% were Artisans while the highest secondary occupation of the respondents was trading (36.67%). The mean income of the respondents was ₦6,883.33. The average income from secondary occupation was ₦21,075. The empowerment programmes benefited by the women through their Local Government Areas were: Workshop by extension Personnel, (85.83%) Agricultural facilities, (85.83%), access to Micro-credit programme (80.83%), Adult literacy programme (45.83%), access to media (63.33%), and Skill/ technical training. (76.67%). The result revealed that majority of the respondents (70.83%) were moderately empowered,, 9.11% had the privilege of participating in almost all the empowerment programme,s while 20% of the respondents had a very low access to empowerment programmes. The result also revealed that age was negatively significant while primary occupation, secondary occupation, number of children and rating of women involvement were positively statistically significant to women economic status in the study area. Women were involved in empowerment programme on the average and it has helped them to be more established in their businesses but their income is not justifying these efforts and therefore, that empowerment programme should be reviewed to formulate constructive policy that will improve economic empowerment of rural women and promote the economic development of the country.
Keywords: *Assessment, Economic, Empowerment, Women*

INTRODUCTION
Women's economic empowerment means expanding women's economic opportunities in terms of both labour market access and productivity (Peters *et al*., 2016). It also involves the creation of an environment within which women can make strategic life choices and decisions in a given context (Leder, 2016). . Empowering women especially in rural communities does not only increase the wealth of the nation but bridges the gap of gender inequality where women also own means of production and can be employers of labour (Oluwatoyin, 2013). Empowerment has been observed to be one of the major concerns when addressing the issue of human rights and development (Tripathi, 2011). Women's empowerment is one of the priorities of the proponents of development approach, and has been a major area of investigation in human development research in the last two decades (Acharya *et. al*., 2010; Khan and Awan, 2011; Wiklander and Thede, 2010; Batool and Batool, 2018).

Women's empowerment could be characterized into four major domains: socio-cultural, economic, education, and health (Ashaolu *et al*., 2018). There are different concepts in measuring women empowerment, but similarities can be found in literature. Some of the themes frequently used to conceptualize women's empowerment are household decision-making, economic decision-making, access to resources, and physical mobility (Hameed *et, al.*, 2014; Sharma, 2015; Mahmud, 2012; Yaya *et al.*, 2018). Thus study is based on the empowerment programmes benefitted by the women in the Local Government Area this study was conducted.

Different statistical techniques have been used by researchers to find out the determinants of women's empowerment. Most of the researchers preferred to use descriptive statistics and Ordinary Least Square analyses e.g., Haque et al. (2011), Khan and Maan, (2008), Sheikh et al. (2015), without giving justification to use a particular method for particular data analysis. Whereas, some of the researchers do not support the use of Binary Logit Regression as it restricts the dependent variables (e.g., women's empowerment) to dichotomous categories: least empowered and highly empowered that would result in a loss of very vital information about the dependent variable. This study uses ordered probit regression due to the case of more than two outcomes of an ordinal dependent variable (a dependent variable for which the potential values have a natural ordering, as in poor, fair, good, excellent). The general objective of this study was to assess the empowerment status of women in Ibarapa Central Local Government of Oyo state. The specific objectives were to:

i. describe the socio-economic characteristics of the respondents;
ii. identify the Government empowerment programmes available in the study area ;
iii. estimate the empowerment status of rural women in the study area; and
iv. analyze the effect of socio-economic characteristics on the empowerment status of women in the study area.

MATERIALS AND METHODS

The study was conducted in Ibarapa Central Local Government Area of Oyo State of Nigeria. Oyo State is one of the 36 States in Nigeria and it lies in the South- western part of the country. The state with two ecological zones is well suited for food crop production. Food crops grown in the area include Yam, maize, cassava, cowpea, plantain and rice. The LGA came into existence in 1996. According to the 2006 census, it has population of 102,979. The study area shares boundary with Ogun state in south, bounded in the east by Ibarapa East LGA, to the west by Benin Republic and to the North by Ibarapa North Local Government.

The Local Government is heterogeneous and dominated by the Yorubas, others include Ghanaians, Hausa, Fulani and Agatu residing in the area. The location enjoys the wet and dry seasons and the rainfall in the follows a topical type with an average annual rainfall that ranges from1850mm to 2250mm and the average annual temperature between 27oC and 27^0C. Primary data were used for this study with the aid of a well-structured questionnaire. Multi-stage sampling techniques were used to collect data for the study. Idere and Igboora are the two main towns in Ibarapa central L.G.A. Igboora has 7 wards while Idere has 3 wards making 10 political wards. The first stage was random selection of 4 wards from the 10 political wards. The second stage wass random selection of 32 households from each of the selected wards. The third stage was purposive selection of women in each household. The second stage was random selection of 2 households from each of the six (6) wards. The third stage was random selection of 12 women from rural households. Altogether, 128 women were interviewed and a total of one hundred and twenty (120) respondents were found worthy for this study. The information was gotten through the Local Government list of rural households.

Descriptive Statistic such as frequency count, percentage and mean scores were used for objectives 1 and 2, likert scale was used for objective 3 while inferential statistics i.e. ordered probit regression was used for objective 4.

Following William (2012) and Diebold (2014), suppose the underlying relationship to be characterized:

$Y^* = X^T\beta + \varepsilon$

Where Y* is the exact but unobserved dependent variable and perhaps the exact level of improvement by the respondent. X is the vector of independent variables and β is the vector of regression coefficients which we estimate.

While we cannot observe Y*, instead we can only observe the categories of response:

$$Y = \begin{cases} 0 \ \text{if } y^* \le 0 \\ 1 \ \text{if } 0 < y^* \le N_{1,} \\ 2 \ \text{if } N < y^* \le N_2 \\ \\ N \ \text{if } N_{N-1} < y^* \end{cases}$$

=> Then the ordered probit technique will use the observations on y which are forms of censored data on y* to fit the parameter vector β.

Note: The model cannot be consistently estimated using OLS; it is usually estimated using maximum livelihood.

Measurement of Variables

Empowerment Status: Government Empowerment Program (Social factors) available in the Local Government Area for this study was used to generate empowerment status of the respondents and doubles as the dependent variable. The independent variables include the demographic factors and economic factors. (Didana, 2019; Liddell and Kruschke (2018)

Indicators: Access to resources, social factors, economic factors, demographic factors

ORDERED PROBIT MODEL:

Y = Empowerment Status (1 =low, 2= medium/ moderate , 3 = high).

X_1 = Age (years), X_2 = Household size, X_3= Marital status, X_4 = Primary Occupation X_5= Secondary occupation

X_6 = Educational level (year), X_7= Number of children, X_8 = Rating of women involvement, e = error term

RESULTS AND DISCUSSION

Objective 1: Socioeconomic Characteristics of the Respondents

Table 1 revealed. 24.17% of the respondents were less than or equals to 30 years old, 53.33% were between the ages of 31 and 40 years, 16.67% were between ages 41 – 50 years while 5.83% were above 50 years of age. The mean age was 36years old. This implies that most of the women were in their economic active age. Household size of the respondents revealed that 22.5% of the respondents had less than 3 members in their household, 62.50% of the respondents had between 3 – 4 household size, 14.17% had household size of 5 and 6 members while 0.83% of the respondents had household size of just 1 member. The mean household size was three.

The marital status of the respondents revealed that 90.83% of the women were married, 7.5% were widowed while 1.67% were divorced/separated. It implies that majority of the women in the study area were married. Educational status of the respondents revealed that 30% of the respondents had primary school education, 55.83% of the respondents had secondary school education, 10% of the respondents had tertiary education while 4.17% of the respondents had no formal education. It implies that greater percentage of the respondents had Secondary school education. The religion of the respondents revealed that 42.5% of the respondents were Christians, 43.33% were Muslims while 14.17% of the respondents were traditional worshipers. The number of children in the household revealed that 41.67% had less than or equals to 3 children, 50.83% had between 4 and 6 children while 7.5% of the respondents had 7 or more children in their household. Primary occupation of the respondents revealed that 45% were Artisans, 14.17% were traders, 25.83% were farmers while 15% were Civil Servants. The secondary occupation of the respondents revealed that 31.67% were Artisans, 36.67% were into trading, 18.33% were into farming while others were 13.33%.

Income from primary occupation revealed that 29.17% earned less than or equals to #10, 000 per month, 54.17% of the respondents earned between #10, 001 and N20, 000 per month, 14.17% had income range of #21, 000 – #30, 000 per month, 1.67% earned between #30, 001 and #40,000 per month while 0.83% of the respondents earned #40, 000 and above per month. The mean income of the respondents was #16,883.33.

The Secondary occupation of the respondents revealed that 6.67% of the respondents earned less than or equals to #10, 000 per month, 56.67% earned between #10, 001 and #20, 000 per month, 33.33% earned between #21, 000 and #30, 000 per month, 1.67% of the respondents had an income range of #30, 001- #40,000 per month and greater than #40,000 per month respectively.

Table 1: Socioeconomic Characteristics

Variables	**Frequency**	**Percentage(%)**	**Mean**	**Std**
Age				
≤ 30	29	24.17	35.85	6.3041
31 – 40	64	53.33		
41 – 50	20	16.67		
> 50	7	5.83		
Household size				
< 3	27	22.5	3.3	1.1924
3 – 4	75	62.50		
5 - 6	17	14.17		
>7	1	0.83		
Marital status				
Married	109	90.83		
Widowed	9	7.50		
Divorced	2	1.67		
Educational level				
Primary	36	30.00		
Secondary	67	55.83		
Tertiary	12	10.00		
No Schooling	5	4.17		
Number of children				
≤ 3	50	41.67	3.8	1.61193
4 – 6	57	50.83		
≥7	9	7.5		
Primary Occupation				
Artisan	54	45.00		

Trading	17	14.17		
Farming	31	25.83		
Civil Service	18	15.00		
Secondary Occupation				
Artisan	38	31.67		
Trading	44	36.67		
Farming	22	18.33		
Others	16	13.33		
Income (#) (Primary Occupation)				
<10000	35	29.17	16883.33	611.561
10,001 – 20,000	65	54.17		
20,001 – 30,000	17	14.17		
30,001 – 40,000	2	1.67		
> 40,000	1	0.83		
Income (Secondary Occupation)				
<10000	8	6.67	21075	602.982
10,001- 20,000	68	56.67		
20,001 – 30,000	40	33.33		
30,001 – 40,000	2	1.67		
>40,000	2	1.67		
TOTAL	**120**	**100.00**		

Source: Field survey, 2019

Objective 2: Government Empowerment Programs Benefited by Women

The result in Table 3 revealed that 85.83% of the respondents benefited from Workshop by extension Personnel, 85.83% had access to Agricultural facilities, 80.83% had access to Micro-credit programme, 45.83% had access to Adult literacy programme, 63.33% had access to Access to media while 76.67% benefited from Skill/ technical training.

Table 2. Government Empowerment Program Benefited by the Women

Empowerment Prog	Yes Frequency/Percentage	No Frequency/ Percentage	Total
Workshop by extension Personnel	102(85.83)	8(14.17)	120/100
Provision of Agricultural facilities	103(85.83)	7(14.17)	120/100
Micro- credit programme	97(80.83)	23(19.17)	120/100
Adult literacy programme	55(45.83)	65(54.17)	120/100
Access to media	76(63.33)	44(36.67)	120/100
Skill/ Technical Training	92(76.67)	28(23.33)	120/100

Source: Field survey, 2019

Objective 3: Estimation of Empowerment Status of the Women.

To estimate the empowerment status of the respondents, empowerment index was firstly generated through the weighted average of the responses to empowerment programmes and benefits. The index was between 0 and 1. Empowerment benefits/ programmes: Workshop by extension Personnel, Provision of Agricultural facilities, Micro-credit programme, Adult literacy programme, Access to media and Skill/ technical training.

Table 3.1 : Empowerment Index(EI)

Empowerment Index	FREQUENCY	PERCENTAGE(%)
0	-	-
0.1666	6	5.00
0.3333	19	15.83
0.5	37	30.83
0.6666	3	2.50
0.6667	44	36.67
0.8333	11	9.17
1	-	-
TOTAL	**120**	**100.00**

Empowerment Status of the Women

Table 3.2 Empowerment Status (ES)

Empowerment Status was categorized into low (1), medium (2) and high (3) of the weighted average of the responses. The result revealed that majority of the respondents (70.83%) were moderately empowered in the study area, 9.11% had the privilege of participating in almost all the empowerment programme, while 20% of the respondents had a very low access to empowerment program in Ibarapa Central Local Government area of Oyo State.

Table 3.2: Distribution of the Empowerment Status of the Women

Empowerment Status	Frequency	Percentage (%)
1 (LOW)	24	20.00
2 (MEDIUM)	85	70.83
3 (HIGH)	11	9.17
TOTAL	**120**	**100.00**

Objective 4: Determine the effect of some socioeconomic characteristics on empowerment status of women in the study area

Ordered probit model was used for this objective. The dependent variable (Y) is the empowerment status (1=low, 2= moderate, 3= high) while the independent variables $X_1 \ldots X_8$ are age, household size, marital status, educational level, primary occupation, secondary occupation, women's involvement and number of children, which were used as inputs for the ordered probit model. The factors were tested for statistical significance (p value < 0.05) to find out the factors that significantly influenced the empowerment status on some socioeconomic characteristics of women in Ibarapa central local Government area of Oyo State.

The result revealed that the age, primary occupation, secondary occupation, number of children and rating of women involvement are statistically significant. The age is negative and statistically significant at 1%. Increase in age decreases empowerment status at 0.08 and implies that the aged were not opportune to participate in empowerment program. Primary occupation is positive and statistically significant at 5%, having a primary occupation influence positively the empowerment status of the respondents at 0.24. This is in line with the study carried out by Ahmed (2013) that employment/ doing any paid work is the identified determinants of women economic empowerment and also, women carrying out these income generating activities always look for new income generating activities. So, they readily become empowered.

For a one unit increase in secondary occupation, we would expect 0.20 decreases in the log odds of empowerment status. Also, for a one unit increase in rating women involvement, we would expect 0.76 decrease in the log odds of empowerment status of the respondents and lastly, the number of children is positively significant, increase in number of children increase the empowerment status of the respondents at 0.15 given that all of the other variables in the model remain constant.

Table 4. Ordered probit regression

Number of obs = 120		LR chi2(8) = 36.47		
Prob > chi2 = 0.0000				
Log likelihood = -75.988477		Pseudo R2 = 0.1935		
PROBIT				
Economic status	Coef	std err	Z	P>\z/
Age	-0. 0824977	0. 0258078	-3.20***	0.001
Household size	-0. 0653738	0. 1239695	0.53	0.598
Marital Status	0.4386646	0. 4562317	0.96	0.336
Education level	0. 011085	0. 1691781	0.07	0.948
Primary occupation	0. 2014201	0. 1140891	1.77*	0.077
Secondary occupation	-0. 2002967	0. 0972583	-2.06***	0.039
Women involvement	-0. 7595564	0. 2546376	-2.98***	0.003
Number of children	0. 1506513	0. 0756859	1.99**	0.047

Level of significance *= 10%, **=5%, ***=1%

SUMMARY AND RECOMMENDATION

Summary

The summary of the socioeconomic characteristics of the women revealed that the mean age was 36years old. The mean household size was 3. 90.83% of the women were married, 55.83% of the respondents had secondary school education, the average number of children was 4. Primary occupation of the respondents revealed that 45% were Artisans while the highest secondary occupation of the respondents was into trading (36.67%), 18.33%. The mean income of the respondents was #16,883.33. The average income from secondary occupation was #21,075.

The empowerment programs benefited by the women through their Local Government areas follow: 85.83% benefitted from Workshop by extension Personnel, 85.83% had access to Agricultural facilities, 80.83% had access to Micro-credit programme, 45.83% had access to Adult literacy programme, 63.33% had access to Access to media while 76.67% benefited from Skill/ technical training. Empowerment Status was categorized into low (1), medium (2) and high (3) of the weighted average of the responses. The result revealed that majority of the respondents (70.83%) were moderately empowered in the study area, 9.11% had the privilege of participating in almost all the empowerment programme, while 20% of the respondents had a very low access to empowerment program in Ibarapa Central Local Government area of Oyo State.

Orderd probit was used to determine the effect of some socioeconomic characteristics on empowerment status of women in the study area The result revealed that age was negatively significant while primary occupation, secondary occupation, number of children and rating of women involvement are positively statistically significant to women economic status in the study area. In summary, women were involved in empowerment programme on the average and it has helped them to be more established in their businesses but their income is not justifying these efforts and therefore, that empowerment programme should be reviewed.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations were made:

1. Women empowerment programs should cut across all age categories
2. Government and non -governmental organizations should intensify more efforts to review the existing empowerment programs so that most women will benefit maximally to improve the well-being of their household.
3. The empowering agencies (e.g. governments, non-governmental bodies, individuals) should create necessary awareness on the availability of the existing empowerment initiatives so that women can take advantage of these initiatives.
4. Access to financial credits and facilities will boost their day to day activities and economy.

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SOCIO-ECONOMIC DETERMINANTS OF WOMEN ADOPTION OF RECOMMENDED CASSAVA PROCESSING TECHNOLOGIES IN FEDERAL CAPITAL TERRITORY (FCT), ABUJA, NIGERIA

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ABSTRACT

The study analyzed the socio-economic factors influencing adoption of recommended cassava processing technologies among women cassava processors in Federal Capital Territory, Abuja, Nigeria. A multi-stage sampling was used to draw a sample size of 153 respondents for the study. Data were collected through the use of questionnaires. Both descriptive and interferential statistics were used to analyze the data collected from the field. The results showed that majority (76.5%) of respondents were within the age range of 20 – 40 years with a mean age of 35 years and majority (75.2%) had various forms of formal education with at least secondary education with a mean household size of 7 persons. Majority had the mean years of 8 years' experience in processing cassava. The coefficient of determination (R^2) was computed at 0. 637. The variables; level of education (sig.=0.070), years of cassava processing experience (sig.=0.037), and number of extension contacts (sig.=0.053) exhibited positive significant relationship at p-value less than or equal to 0.05 while age (sig.=0.051), though significant was negatively related at p-value less than or equal to 0.05. It was recommended that Stakeholders and government agencies with requisite mandate to increase investment on processing technologies and subsidize processing machines in order for women to access them and increase the level of adoption.

Keywords: *Smallholder farmers, agricultural credit, determinant, accessibility, formal agricultural credit*

INTRODUCTION

In Nigeria Cassava production and processing has boosted agriculture and it is traditionally regarded as the mainstay of the Nigeria economy as it supplies food, raw materials and generates household income for the majority of the people. Cassava processing is important in making food available and is often carried out by women. Ogadinma *et al.* (2019) stated that women in cassava production and processing could be developed by the provision of improved cassava varieties, use of fertilizer, use of agro-chemicals, and use of mechanized farming equipment and modern processing techniques. The traditional processing techniques are laborious, time wasting and may result in poor products.

Mechanization of cassava processing can solve these constraints of cassava processing. The choice of machines for making a cassava product depend on the unit operations involved in its production process. Emphasis is therefore placed on appropriate technology for increasing food availability through increased processing, quality control, and preservation. Modern processing technologies such as the mechanical grater, power screw dehydrating press, mechanical sifter, fryer (toaster) and stitching machine have been introduced by Fadama II programme to some women cooperatives in Gwagwalada Area Council. The extent to which these technologies are being adopted by processors to reduce drudgery during processing and increase output is not yet clear. Studies that will reveal the level of adoption of recommended cassava processing technologies by women processors and how they affect the quality and quantity of the processed products is important. Therefore, the need to probe into the level of adoption of recommended cassava processing technologies by women especially in the study area to give a direction on how to guide women processors of cassava on where and how to access them makes this study imperative.

This study, therefore, was designed to analyze the socio-economic factors influencing adoption of recommended cassava processing technologies among women cassava processors in Federal Capital Territory, Abuja.
Hypothesis was designed as tested in null form as presented below;.
Ho: There is no significant relationship between the women's socio-economic characteristics and the adoption of recommended Cassava processing technologies in the study area.

METHODOLOGY

The study was conducted in the Federal Capital Territory (FCT) which is located in the North Central Nigeria. The Federal Capital territory Abuja is located in the center of Nigeria, between latitudes 8^o 25^1 and 9^o 25^1 north and longitudes 6^o 45^1 and 7^o 45^1 east. The territory covers an area 8,000 square kilometers, laying in the centre of the country and is bordered on all side by four states namely; Niger, Nasarawa, Kogi and Kaduna (Dawan, 2000). A multi-stage sampling procedure was used to select the respondents. Stage I: Three area councils were purposively selected out of the six (6) area councils of Federal Capital Territory (FCT). The 3-area councils (Gwagwalada, Kwali and Abaji) were purposively selected due to cassava processing activities common to the areas. Stage II: Random selection of 4 villages in each of the 3 councils to give a total of 12 villages and followed by proportionate selection of 50% of the sample frame from each of the 9 villages to give a total sample size of 153 respondents for the study.
Data collection was achieved using questionnaires administered to respondents through the agricultural extension agent and analyzed using both descriptive and inferential statistics.
Linear production function will was used to determine the socio-economic factors influencing adoption of recommended cassava processing technologies by respondents. The linear production function is expressed as shown below:

$Y = a + b_1X_1+b_2X_2+ b_3X_3+ \_\_\_\_ + b_{12}X_{12} + e$

Where Y = Number of adopted recommended processing technologies adopted by respondents expressed in percentage

$$Y = \frac{\text{No. of recommended technologies adopted}}{\text{Total available recommended cassava processing technologies}} \times 100$$

X_1 = Age (in year)
X_2 = Marital status (Single = 1, Married = 2, Divorced = 3, widowed = 4)
X_3 = Educational level (No. of years spends in school)
X_4 = Household size (in number)
X_5 = Processing experience (No. of years spend in processing)
X_6 = Contact with extension agent (No. of visit)
X_7 = Access to credit (amount in ₦)
X_8 = Membership of cooperative group (No. of years)
X_9 = Amount of income (in naira)
X_{10} = Affordability of technologies (if yes = 1, no = 0)
X_{11}= Compatibility of technologies (compatibility = 1, not compatibility = 0)
X_{12} = Complexity of technologies (complex = 1, if not complex = 0)
b_1– b_{12}= régression coefficients
a = constant
e = error term

RESULTS AND DISCUSSION

Socioeconomic characteristics of respondents

Results in Table 1 shows a mean age of 35 years with about 22% attained secondary school education having an average household size of 7 with majority (56.2%) polling a household size of 6-10 persons. Majority (43.8%) of respondents have spent 6 – 10 years in cassava processing with an average 8 years' experience. Also, Table 1 revealed 53.6% were members of cooperative societies whereas 46.6% do not belong to any cooperative societies with the majority (66.0%) having contact with extension agents who come regularly to discuss the availability of rice processing technologies and how to access them. Most (53.6%) of respondents have access to credit facility from various informal credit sources, the bulk of the credit comes from relatives and friends (15.0%). Table 1 also showed that majority of the respondent (65.4%) received training, which has helped in improving their processing activities and the quality of cassava products they produced.
These results showed that respondents were youthful and in their active years with various forms of formal education, as such could undergo the rigors of cassava processing and could make informed decisions in adopting recommended best practices. Years of experience in cassava processing also reflect their occupational commitment and efficiency on the employment of processing technologies. Ezeano *et al.* (2017) reported that women processors were experienced in cassava processing experience and experience plays a significant role in adoption of technologies.

Table 1: Socio-economic Characteristics of Respondents in the Study Area

Socio-economic variable	Frequency	Percentage (%)	Mean
Age(years)			
20-30	59	38.6	
31-40	58	37.9	**35.2 years**
41-50	25	16.3	
Above 50	11	7.2	
Educational Status			
No formal education	38	24.8	
Primary education	37	24.2	
Secondary education	44	28.8	
Tertiary education	34	22.2	
Household size (persons)			
1-5	46	30.1	
6-10	86	56.2	7 Persons
11-15	18	11.8	
Above 15	3	1.9	
Years of experience in cassava processing (Years)			
1-5	50	32.7	
6-10	67	43.8	**8 Years**
11-15	32	20.9	
Above 15	4	2.7	
Cooperative membership			
Yes	82	53.6	
No	71	46.4	
Years of cooperative membership (number of years)			
1-5	22	26.8	
6-10	54	65.9	**3 Years**
11-15	5	6.1	
Above 15	1	1.2	
Extension contact			
Yes	101	66.0	
No	52	44.0	
Number of extension contacts (number of times)			
1	31	30.7	
2	46	45.5	
3	24	23.8	
Access to credit			
Yes	82	53.6	
No	71	46.4	**73,835.44 Naira**
Amount of loan accessed (in Naira)			
1-50,000	49	59.8	
50,001- 1,000,000	17	20.7	
1,000,001-1,500,000	11	13.4	
Above 1,500,000	5	6.1	
Training received			
Yes	100	65.4	
No	53	34.6	
Total	**153**	**100.0**	

Source: Field survey, 2019

Socio-economic Determinants of the adoption of recommended cassava processing technologies by respondents in the study area.

The results of the regression analysis as presented in Table 2 show that the coefficient of determination (R^2) was 0.637 implying that the independent variables explain 63.7% of the variability of the dependent variable. The variables of level of education (sig.=0.070), years of cassava processing experience (sig.=0.037), and number of extension contacts(sig.=0.053) exhibited positive significant relationship at p-value less than or equal to 0.05 while age (sig.= 0.05), though, significant was negatively related at p-value less than or equal to 0.05.

The variable of education was positive and significant at 5%. This show there exists positive and significant relationship between years of education and adoption of recommended cassava processing technologies among women cassava processors in the study area. The estimates of the probit analysis by Akinloye (2014) showed how the coefficients of the independent variables influenced the adoption of improved cassava technologies of the small-scale women entrepreneurs. The results showed that educational status was one of major determinants of adoption at 5% significant level in the study area. This means that the more educated the women entrepreneurs are, the likelihood of being able to adopt improved cassava processing technologies. **Y**ears of experience was positive and significant at 5%. This implies that the more experienced the women cassava processors are, the more the likelihood of being able to adopt improved cassava processing technologies. This also implies that the more experience women acquire in processing cassava will lead to increases in knowledge, confidence and perfection, which will invariably increase their participation level.

The variable of contacts with extension workers was positive and significant at 5%. Extension contact is one of the main sources of production and technologies information for improved methods of agricultural activities for farmers. The significant effect of contacts with extension agents in the study area could also result to women cassava processors having professional and technical information/advice on their cassava processing activities. Age was negatively significant at 5%. Age had a negative regression coefficient meaning that as age increases, adoption of improved cassava processing technologies decreases. The implication of this result is that cassava processing in the study area was done by young women who were in their productive age. Their energies could be utilized in the handling of improved cassava processing technologies. Augustine (2015) showed that age had a negative regression coefficient of 0.048 and had significant influence on the adoption of improved cassava processing technologies at 1% level of probability. This implies that the adoption of the improved cassava processing technologies decreases with an increase in age.

Table 2: Regression Results on Socioeconomic Characteristics on Adoption of Technology

Model	**Unstandardized Coefficients**		**Standardized Coefficients**		
	B	**Std. Error**	**Beta**	**T**	**Sig.**
(Constant)	4.138	1.889		2.190	.071
Age	-1.521	.627	-2.361	-2.426	.051
Marital Status	1.843	1.482	.790	1.244	.260
Education Years	.132	.060	1.021	2.196	.070
Household	-.103	.088	-.422	-1.167	.287
Years in Cassava Processing	1.198	.448	1.898	2.674	.037
Times visited by the extension agents	1.430	.595	1.543	2.405	.053
Credit Amount	1.114E-5	.000	1.334	1.560	.170
Years in cooperative society(s)	-2.381	1.584	-1.666	-1.503	.184
Affordability	-.007	.168	-.011	-.040	.969
Compatibility	.049	.438	.051	.111	.915
Complexity	.099	.466	.084	.212	.839

Source: Field survey, 2019

Test of Hypothesis

The results of the f-statistics showed that there was significant interaction between respondents' level of education, years of experience and extension contacts were significant and positive determinants of adoption of improved cassava technologies at p-value less than or equal to 0.05. The t-value that is absolutely greater than 2 shows that years in cassava processing is the most determinant factor. Age had a negative regression coefficient of -1.5 meaning that as age increases, adoption of improved cassava processing technologies decreases. Therefore, based on the F-statistics on the ANOVA table, the null hypothesis is rejected.

Table 3: Relationship between the women's socio-economic characteristics and the adoption of recommended Cassava processing technologies

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	3.699	12	.308	**1.169**	**.425[b]**
	Residual	2.110	8	.264		
	Total	5.810	20			

Source: Field survey, 2019

CONCLUSION AND RECOMMENDATIONS

There is no significant relationship between the women's socio-economic characteristics and the adoption of recommended Cassava processing technologies in the study area and recommends the need to train more women on the available improved cassava processing technologies as knowledge precedes adoption. Stakeholders and government agencies with requisite mandate need to increase investment on processing technologies and subsidize processing machines in order for women to access them and increase the level of adoption.

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ASSESSMENT OF WOMEN FARMERS' ACTIVITIES IN FOOD CROPS PRODUCTION IN LAFIA LOCAL GOVERNMENT AREA OF NASARAWA STATE, NIGERIA

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ABSTRACT
The study was conducted to assess women farmer's activities in food crops production in Lafia Local Government Area of Nasarawa State, Nigeria. Primary data were collected with the use of structured questionnaire employed to select 120 respondents for the study using a simple random sampling technique. Descriptive and inferential statistics were employed to analyze the data collected. The result of the study revealed that the mean age of the respondents was 42 years, which were found to be married. It was also discovered that respondents carried out farming activities such as land clearing, cultivation/ridging/heaping, seed planting, fertilizer application, chemical application, processing and marketing. Major crops identified in the study area were maize, yam, cassava, sorghum and rice. Result from the Cobb Douglass production function on factors that influence the income of the farmer were farm size (0.33), level of education (0.171), extension visit (0.017), membership of farmers association (-0.459), labour (0.573), transportation (-0.243) and age (0.038). Major constraints faced by the respondents were inadequate capital, high cost of input and inadequate extension visit in the study area. Furthermore, it is observed that women farmers engaged in various farming activities. It was recommended that the Government need to distribute farm inputs to women farmers at a very subsidized price and at appropriate time to boost production.
Keywords: *Assessment, women farmers, food, crop production*

INTRODUCTION
Agriculture contributes immensely to the Nigerian domestic production with the sector accounting for about 25.52 % of the GDP and employ over 50 % of the labour force (Elijah, *et al.*, 2017; NBS, 2019). It plays important roles in the socio-economic development of developing countries such as Nigeria in the provision of food for the increasing population, supply of raw materials and a major source of employment, generation of foreign exchange earnings, and provision of market for the products from the industrial sector (Eze *et al.*, 2010). In Nigeria, women's contribution to agriculture is estimated at 60-79 percent of labour, especially for food production, processing and marketing (FAO CPF, 2012-2017) and participate in sowing, weeding, harvesting and storing crops and other, they also carry out non-farm activities such as food processing and trade in agricultural products (Houinsa, 2013). Many women are farmers in their own right, as well as working on family farms.
The activities that women involve in meeting the challenges of agricultural production and rural development are quite enormous (Nuhu *et al.*, 2014; Egwuonwu, 2017) and their relevance and significance is therefore prominent in Nigeria. The rural women play key role in supporting their households and communities in achieving food and nutrition security, generating income and improving rural livelihoods and overall wellbeing (Nnadi *et al.*, 2012). Women are the key to the well- being of their families (UNESCO, 2017).
As of 2020, around 32 percent of women in Nigeria were employed in agriculture, forestry, and fishing. The share slightly decreased from the previous year. Generally, since 2000, Nigeria's female employment in agriculture, forestry, and fishing has declined. (Sasu, 2023) Women are responsible for about 50 per cent of the world's food

production and in some countries of sub-Saharan Africa (including Nigeria), women provide between 60 and 80 per cent of the food for household consumption. Women's contribution to agricultural production varies from country to country, crop to crop and task to task (Marilee, 2009). Hence, no meaningful household food security can occur without women who make up more than one half of the rural population. Exact data is very hard to come by but FAO estimated that women are the main producers of the world's staple foods like maize, cassava, wheat and rice. Most of the activities which women engaged in are not defined as economically active employment in national account systems, yet are crucial to the wellbeing of household members (FAO, 2010).. They also perform tasks in household crop production; including sowing seeds, weeding, applying fertilizers and pesticides, harvesting and threshing of the crops. They are also responsible for post-harvest food processing, storage, transport and marketing. In addition to producing staple crops, women in many countries also grow legumes and vegetables to feed their families (Marilee, 2009).

For some years now, the various layers of government have made massive transformative effort towards modernizing agriculture to transform it to modern contemporary systems of food crop and livestock production by Government. Resources have been invested in different phases of agricultural enterprises in an attempt to improve the necessary input, distribution and marketing systems to increase yields yet. The controlled by men. Of these resources mostly invested in men. Women are discriminated against in ownership of land, production resources and farm decision making. This attitude stands from ignorance of the roles women play in agricultural production. This poor recognition inevitably results in loss of interest in farming and non-acceptance of innovations on the part of women. Inspite of the established Women in Agriculture (WIA) programmes was established to create awareness and about the level of women's participation in agriculture. The WIA has been on for more than 2 decades..However, the women farmers are still experiencing challenges of accessing production inputs, new inovations among others. The need therefore, to assess the activities of women farmers in food crop production in Lafia local Government area of Nasarawa State**.** To achieve this there is need to find answers to the following research questions.

i. What are the socioeconomic characteristics of women farmers in food crop production activities in the study areas?
ii. What are the major activities carried out by women farmers?
iii. What are the major food crops planted by women farmers?
iv. What are the factors that affect income generated by women farmers?
v. What are the constraint facing women farmers in the areas?

Objectives of the Study

The broad objective is to assess women farmers' activities in food crop production in Lafia Local Government Area of Nasarawa State. While, the specific objectives are to;

i. describe the socioeconomic characteristics of women farmers in food crops production.
ii. identify major activities carried out by women farmers.
iii. identify major food crops grown by the respondents.
iv. determine factors that affect income generation by women farmers.
v. identify constraints facing women farmers in the areas

METHODOLOGY

The study area

The study was carried out in Lafia local Government Area (LGA) of Nasarawa State, Nigeria. It is bounded by Obi LGA in the South, Nasarawa-Eggon LGA in the North, Doma LGA in the West. Lafia is located on latitude: 8° 29'38.04"N and longitude 8° 30'55.15"E.The mean monthly maximum and minimum temperature at 35.06 ^{0}C and 20.16 ^{0}C respectively while rainfall is about 168.90mm (NIMET, 2008). It has a population of 330,712 people (National Population Census, 2006). The people are mainly farmers. They grow food crops, cash crops and rear animals.

Sampling technique and sampling size

The study employed multi-stage sampling techniques for the selection of respondents. The first stage was the purposive selection of Lafia LGA. The second stage involved the purposive selection of 8 wards due to high concentration of women farmers. The third stage was the random selection of 15 women farmers from each of the selected wards making a total of 120 women farmers and used as the respondents for the study.

Method of data collection

Primary data that was used for the study and was collected with the use of structured questionnaire. The information that were collected were on the socioeconomic characteristics of the women farmers.

Method of data analysis

Descriptive and inferential statistics were used to analyze the data. Descriptive statistics were used to satisfy objectives i, ii, and iii while double log production function was used to achieve objective iv of the study. The model is of double log is specified as follows:

Double log: $Y= ax_1^{b1}x_2^{b2}e$

$Logy=loga+logb_1x_1+logb_2x_2+logb_3x_3+logb_4x_4+logb_5x_5+logb_6x_6+logb_7x_7+loge$

Where

Y= Income in naira (Outputs)
X_1= Farm size (hectare)
X_2= Level of education (year spent in school)
X_3 = Extension visit (number if times visited by extension in year)
X_4 = Membership of farmers association
X_5 = Labour (man/days)
X_6 = Transportation cost (in Naira)
X_7 = age of farmers (in years)
*U*e = Error Term
β_1- β_7 = Regression Co-efficient
B_0= Constant terms

Objective (v) was achieved using Likert scale such as; Very high (3), High (2) and Low (1)

Likert scale

Weighted mean measured through Likert-type three-point continuum scale was used to achieve objective vi. Respondent were asked to indicates the extent of their perception about a statements on a 3-point likert scale using Very high (3), High (2) and Low (1) as a form of measuring degree. Weights of 3, 2 and 1 were assigned. For each indicator a weighted mean obtained as follows:

$$WM= \frac{[(fVS*3)+(fS*2)+fNS*1)]}{N}$$

Where:
WM= Weighted mean, f= frequency, Values 3, 2, 1 = Attached weights; VS, S and
NS= Constraints of very high, high and low
N= Sample size

Deduced following the formula of Bagheri *et al*. (2010) on the perception analysis, the mean(s) for all indicators were measured thus;
The mean(s)
1.00-1.49 (low)
1.50-2.49 (High)
2.50-3.00 (Very High)

RESULTS AND DISCUSSION

Socioeconomic Characteristics of Respondents

The socioeconomic characteristics of the respondents are presented on the table 1. The socioeconomic characteristics of the respondents are an excellent medium for establishing the assessment of women farmers. Socioeconomic characteristics establish behavior patterns that are fundamental to farmers' activities in food crop production.

Age distribution of the respondents: Table 1 shows that 50 respondents representing 41.66 %were within the age range of 21-40 years suggesting the population was young age categories that facilitate the energy demanding labour in crop production activities. About 65 respondents representing 54.19% were between the ages 41-60 years suggesting that the population are still in their active age categories. While those that aged greater than 60 years made up 4 %. The mean age of the respondents in the study was 42 years, the age distribution suggest that population was young.

Distribution of the respondents according to Marital Status: Table 1 shows that most of the respondents (62.50 %) were married while 12.50 %, 10.00 % and 15.00 % of the respondents were single, widow and divorced respectively. This mean that women farmers are mostly married followed by significant proportion of divorced, single and widows. Married women farmers often have greater engagement and more likely participated in agriculture as a means to support the family and they also have the advantage of applying family labour to their operations and likely to dedicate more land to farming.

Distribution of the respondents according to Educational Qualification: Table 1 also indicated that most 50(41.67%) of the respondents had acquired primary education, likewise 25(20.83%) of the respondents had acquired secondary education and 15(12.50%) of the respondents acquired tertiary education while 30 (25.00%) of the respondents were non-formal educated.

Distribution of the respondents according to Farming Experience: The farming experiences of respondents are presented in table 1. The mean years of farming experience among the respondents was 15 years suggesting a spread of the farming experience of the respondents. Most 55 (45.83%) of the respondents had farming experience between 11-20 years and another 39 (32.50%) had farming experience of 1 to 10 years. The least category was respondent with 31-40 years representing 3.33% of the respondents. The findings implies that the respondents have a robust farming experience and with farming experience comes the ability to make better decisions and use the network one has to increase on production activities.

Distribution of the respondents according to Farm Size: The distribution of respondents according to their farm size as depicted in table 1. The mean farm size of the respondents in the study area was 2.32ha which represent an even size of the respondents' farms. It shows that 65.83% of the respondents have 1-5 hectares of land under cultivation. Those with 6-10 hectares of land were 27.5% and those with 11-15 hectares contributed 6.67%. The distribution shows that majority of the respondents' cultivated small hectare of land and such they are mostly small-scale farmers. This could be attributed to the fact that a number of studies have indicated that agricultural production in Nigeria is still characterized by small farm holders.

Extension Visit: The numbers of extension visits received by respondents per annum are presented in table 1. Majority (57.50%) of the respondents had no access to extension visit within the calendar year while only above (42.50%) had access to extension in the same period. This implies that most respondents had no access to extension; their level of access to information about existing new ideas, technology, objects etc will be equally limited.

Membership of Cooperative: Majority (79.17%) of the respondents were members of cooperative while 20.83% were not members of cooperatives. Cooperatives membership is of great advantage to farmers as majority of the lending scheme of formal financial institutions are accessed through the cooperatives platform.

Access to Credit: The accessibility to credit facility by the respondents is presented in table 1. It shows that reasonable percentage (79.17%) of the respondents do not have access to credit facility while (27.5%) have access to credit facility. This indicated that majority of the respondents do not have access to credit facility in the study areas.

Method of acquiring farm: Further analysis of those that owned farms revealed that (66.76%) of the respondents acquired their land through inheritance, (8.33%) acquired their land through gift, (4.17%) acquired their land by share cropping from other individual, 12.50% acquired by lease, (8.33%) of the respondents acquired their land through purchase. Land ownership acquired through inheritance and purchase guarantee production security and freedom and also aid in the acquisition of credit facilities.

Table 1: Socioeconomic characteristics of the respondents

Variables	Frequency	Percentage	Mean
Age (years)			
21-30	10	8.33	42.00
31-40	40	33.33	
41-50	50	41.67	
51-60	15	12.50	
>61	5	4.17	
Total	120	100	
Marital status			
Married	75	62.5	
Single	15	12.5	
Widow	12	10	
Divorce	18	15	
Total	120	100	
Educational Qualification			
No formal Education	30	25.00	
Primary	50	41.67	
Secondary	25	20.83	
Tertiary	15	12.50	
Total	120	100	
Farming Experience			
1-10	39	32.5	14.80
11-20	55	45.83	
21-30	22	18.33	
31-40	4	3.33	
Total	120	100	
Method of acquiring farm			
Inheritance	80	66.67	

Gift	10	8.33	
Share cropping	5	4.17	
Lease	15	12.5	
Purchase	10	8.33	
Total	120	100	
Farm Size (ha)			
1-2	79	65.83	2.32
3-4	33	27.5	
5-6	8	6.67	
Total	120	100	
Extension Visit			
Yes	51	42.5	
No	69	57.5	
Total	120	100	
Membership of Cooperative			
Yes	95	79.17	
No	25	20.83	
Total	120	100	
Access to Credit			
Yes	33	27.5	
No	87	72.5	
Total	120	100	

Source: Field survey, 2021

Activities carried out by women farmers on the farm

Table 2 presents the involvement of women farmers in cropping activities.

Land clearing/cultivation: Land clearing requires the removal of native cover including trees, stalks, and bushes from the land surface. All the respondents were involved in land clearing as the activities carried out on their farm. It has been done to create a workable bed into which a crop can be seeded. Cultivation involved the loosening and breaking up (tilling) of the soil. All the respondents were involved in cultivation, ridging and heaping operation on their farm by hand using hoe while few of them using machine. This is done to destroy weeds and to prepare soil for the planting of crops.

Seed planting/fertilizer and chemical applications: All the respondents were engaged in seed planting, which is done to enable the establishment of the crop on the field. Fertilizer application is indispensable for the proper establishment of the crop on the field. Without fertilizer, the growth of the crop will be affected visa-vis the output at harvest. 100 numbers of the respondents applied fertilizer on their crops for optimum yield. Pre and post emergence herbicide were applied respectively especially rice farmers. 80 numbers of the respondents applied herbicide on their field. Agricultural herbicides are important for weeds control on the farmer's field and for the promotion of plant growth and establishment.

Weeding/harvesting/storage/processing/marketing: Weeding is one of the most important practices in crop production. This entails the removal of unwanted plants from the field. Weeding is necessary because weeds compete with main crop planted for water; sunlight, nutrients and space, hence affect plant growth. Harvesting is the process of removal of entire plants or economic parts after maturity. The economic products maybe grains, seed, leaves, roots and tubers or entire plant. The remaining portion of the stem that is left on the field after harvest is known as stubble. 120 of the respondents were involved in harvesting. Storage means the phase of the post-harvest system during which the produces are kept in such a way to guarantee food security other than during the period of agricultural production. 70 of the respondents stored their produces after harvest. Agricultural processing means transporting, packaging, sorting or grading. Agricultural commodities or plant produces are transforming into goods that are used for intermediate or consumption including goods for non-food uses. Agricultural marketing comprising of all activities involved in supply of farm inputs to the farmers and movement of farm produces from the farm to the consumer. An efficient marketing system ensures higher levels of income for the farmers. 95 of the respondents were involved in marketing their produces.

Table 2: Activities carried out by Women Farmers on the farm

Type of Activities	Frequency
land clearing	120
Cultivation/ridging/heaping	120
Seed planting	120
Fertilizer application	100
Chemical application	80
Weeding	120
Harvesting	120
Storage	70
Processing	65
Marketing	95

Source: Field survey, 2021 Multiple responses

Major crops grown in the study area

Table 4 presented various major crops grown in the study areas in different cropping pattern.

Maize: all respondents were involved in the production of maize. This means that all respondents in the study area were into maize production being the most common and staple arable crop grown by women farmers. Maize is used for human food, livestock feed and export. Maize being an important crop is also among the major crops of comparative advantage in the study area. Yam: 65 of the respondents engaged in the production of yam representing (15.51%), this is because it is the most expensive crop grown in the study area simply because of the cost of its planting material. This implies that not all the farmers can afford yam seeds for yam production. Cassava: 60 (19.09%) of the respondents were engaged in the cassava production. Despite the rapid growth in cassava production, the cassava subsection in the study areas is the cuttings constraint. Rice: 70 (16.71%) of the respondents were involved in rice production which is among the major crop grown in the study area. Some respondents are involved in swamp rice production while others are engaged in semi-swamp and upland rice production. Nevertheless, reasonable numbers of them were into swamp rice farming. Sorghum: 84 (20.05%) of the respondents were involved in sorghum production. Sorghum is a very simple crop that can be grown with little fertilizer and has multifarious usages which is utilized as sorghum meal, malt beer, beer powders, livestock feed among others. It is the most cultivated crop following maize in the study area. Farmers practicing mixed cropping believed that they did so in order to guard against risk of failure of one crop and it diversify their sources of income

Table 3: Major Crops grown in the study area

Types Crops	Frequency
Maize	120
Yam	65
Cassava	80
Rice	70
Sorghum	84
Total	419

Source: Field survey, 2021

Estimate of the Parameters of the Double Log Function on Factors that Influence Income of the Farmers

The result of the Cobb-Douglas production function for input-output relationship in food crop production of women farmers is presented in table 5. The result revealed that the coefficient of multiple determinants (R^2) was 0.719 implying that 71.9% of the variation in the output was explained by the independent variables included in the model. The implication is that the model is good fit. Education, labour, farm size, transportation and membership cooperative were the socioeconomic characteristics determining the respondents income generation. Meanwhile, the regression coefficient for Membership cooperative, labour, farm size and transportation were significant at ($p<0.01\%$).

Labour (0.573) and farm size (0.33) were positive and significantly related to income generated. This implies that 1% increase in labour, farm size and transportation the income will increase by 57.3%, 3.3% respectively. This result highlighted the importance of these variables for increased income generated by women farmers. Similarly, membership of cooperative (-0.459) and transport (-0243) were negative and significant, thus reduction of these variables could lead to decrease in income generated by women farmers.

Education (0.171) was positively related to income generated, this implies that an increase in education the income will increase by 17.1%. However, extension visit and age had positive and not significant influence on income generated; this implies that extension visit and age were not important to income generated by the respondents..

Table 4: Estimate of the Parameters of the Double log Function on Factors that Influence Income of the Farmers

Model	B	Std. Error	t. value
Constant	7.05	1.600	4.407
In_Education	0.171	0.094	1.822*
In-Extension visit	0.017	0.098	0.172NS
In-Membership Cooperative	-0.459	0.104	-4.421***
In_Labour	0.573	0.081	7.088***
In_Age	0.038	0.309	0.124NS
In_Farm size	0.33	0.093	3.534***
In_Transport	-0.243	0.060	-4.080***

R^2= 0.719 ***= Significant at 1%, *= Significant at 10% NS= Not Significant
Adjusted R^2= 0.486 F ratio= 17.106

Constraints Facing Women farmers in the Study Area
The major constraint faced by women farmers in the study area as indicated in table 6 are as thus;
Inadequate capital: the ability for the women farmers to source for capital for their farming activities has been a major constraint that hampers the progress of the farming operation. Table 6 indicate the mean was 2.40, which showed that inadequate capital in the study area was a big problem. Adequate capital is important for the general farm operation. This is because capital is needed from the onset of the farm operation to the harvest.
High cost of input: the high cost of input of the respondents is presented in table 6. The mean score of high cost of input among the respondents was 2.33 accepting an even spread of high cost of input of the respondents. This implies that there is high cost of input of the respondents. The high cost of inputs such as fertilizer, pesticides, herbicides, improved seed variety the most significant factors constraining sustainable women farmers in farming activities in the study area.
Extension visit: the number of extension visit received by the respondents per annum was low with the mean score of 1.64. This implies that since most respondents had no access to extension, their level of access to information about existing new ideas, technology, objects etc will be equally limited. Exposure to extension has also proved to have positive influence on productivity capacity of women farmers.
Scarcity of improved seeds: the scarcity of improved seeds of respondents is presented in table 5. The mean score of scarcity of improved seeds among the respondents was 1.61 rejecting the even spread of scarcity of improved seeds of the respondents. Effective technology of improved seeds can results in higher agricultural production and increased income of farming families, which has positive impact on rural poverty. Seed is the key input for improving crop production and productivity. Increasing the quality of seeds can boost increase the yield potential of the crop by significant sold and thus, is one of the most economical and efficient input to agricultural development. .
Cost of transportation: cost of transportation of the respondents is presented in table 5. The mean score was 1.98, which indicated low. Findings show that transportation plays an important role in the distribution of agricultural product, helps in creating market for agricultural products and reduce spoilage and wastage of farm products. It also shows that improvement in transportation can encourage farmers to work hard in increasing production,
Poor storage facilities: the mean score of poor storage facilities was 1.79. This implies that the poor storage facilities of the respondents are low. Storage of produce is almost as important as growing of crop because when crops are harvested and not stored properly. They are prone to be attacked by storage pest and diseases, which reduce the quantity and quality of the farm produce, thus reducing the income of the farmers.
High incidence of pest and diseases: the mean score of high incidence of pest and disease were 1.78 and 1.30 respectively, meaning that incidence of pest and disease was low in the study area. Outbreaks and upsurges can cause huge losses to crops and pasture threatening the livelihoods of vulnerable farmers and the food and nutrition security of million at a time.
Theft of Products: mean score of theft of products was 1.29 indicating low theft of products. Agricultural crimes includes crops, equipment, chemical and pesticides as well as vandalism and other forms of property crime

Table 5: Constraints Facing Women farmers in the Study Area

Variable Frequency	3	2	1	Score	Mean score	Remark
Inadequate capital	69	32	14	285	2.40	High
High cost of input	50	60	10	280	2.33	High
Inadequate extension visit	53	57	10	197	2.36	High
Scarcity of improved seed	16	41	63	193	1.61	Low
Cost of Transportation	17	83	20	237	1.98	Low
Poor storage facilities	15	65	40	215	1.79	Low
High incidence of pest	14	65	41	213	1.78	Low
High incidence of disease	3	15	102	141	1.30	Low
Theft of products	5	25	90	155	1.29	Low

Source: Field survey, 2021 3- Very High, 2-High, 1- Low,

CONCLUSION

From the result of the study, it is observed that the women farmers engaged in various farming activities. However, they are faced with various degree of constraint in food crop production. Therefore, there is need for the government's response is needed to distribute farm inputs to them at a very subsidized price and at appropriate time to boost production. iii). Extension visit was found to be significantly low, hence, information and messages on improved agricultural innovation that were supposed to be provided and recommendations by the extension officers was discovered to be very inadequate. Therefore, there is an urgent need for by the government to train more extension officers to enable our women farmers have access to improved technologies to boost their farming business. iv). It is obvious that the level of education by respondents is low; therefore women farmers education/training should be given priority. In addition, there is the need for more awareness creation for our educated women to embrace farming as a business. v). One of the major constraint faced by the women farmers is inadequate capital. However, Government should empower them through provision of soft credit facilities with single digit interest rate and anchor borrowers to improve on their income generating activities.

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ANALYSIS OF FACTORS AFFECTING RURAL WOMEN PARTICIPATION IN MAIZE PRODUCTION IN JOS NORTH LOCAL GOVERNMENT AREA (LGA), PLATEAU STATE, NIGERIA

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ABSTRACT
Women participation is essential in household development and sustenance. This study therefore analyzed the factors affecting rural women participation in maize production in Jos North Local Government Area, Plateau State, Nigeria. Questionnaire was used to collect data from a sample of one hundred and eight (108) respondents selected using multi-stage sampling techniques. The first stage involved the purposive selection of eleven (11) communities out of twenty-two (22) communities in the study area based on high participation of women in maize production, while the second stage was the random selection of 11 respondent from each of the selected communities. Data were analyzed using mean scores, standard deviation and factor analysis. Results indicated that the respondents partook in all labour activities involved in maize farming with high-level participation except in very energetic undertakings like earthening – up. Five major factors that affected women participation include Processing/Storage, Soil/Climatic, Labour/Agronomic Technologies, Institutional, and socio-economic factors. The study recommends that respondents should be exposed to scientific and mechanized methods of maize cultivation, harvesting and processing to lessen the drudgery associated with manual labour in maize production practices and gender equality should be advocated to promote equal ease of access to resources and opportunities for women to participate actively in maize production and community development.
Keywords: *Analysis, factors, rural women, participation, maize production*

INTRODUCTION
Maize (*Zea mays* L.) is an important stable cereal crop cultivated in various ecological zones in Nigeria. It plays an important role in the diet and economy of the people especially those in rural communities (Karamara *et al*., 2020). Women play essential roles in maize production - planting, harvesting, processing and preparing of maize based products. Throughout Nigeria, men and women often have complementary roles in maize production activities and in some regions in Nigeria women have distinctly different task and responsibilities in maize production. Rural women have been observed to work side by side with men in maize production with some marked division of labor; while the men performed the tedious tasks of land clearing, gathering, burning of bush and making ridges, women carryout most of the other maize production activities and undertake the general processing (Mba *et al.,* 2017; Marechera *et al.,* 2022). Rural women play a vital role, which is crucial to the overall success of maize production and agricultural development. The role rural women play and their position in meeting the challenges of maize production and development are quite prominent and prevailing. Although both men and women play critical roles in maize farming, harvesting, processing and storage, rural women are usually underprivileged in access to all factors of production and processing in spite of their involvement in general farming operations.

Rural women participation in maize production in Jos North has not only improved food supply but has helped boost food security, reduce poverty, hunger and has enhanced livelihood for rural households. The motivation of rural women to partaking in maize production in the study area is opposed by several constraints, which are likely to affect effort at effectively contributing to food security and sufficiency at both LGA and State level. The question is could high illiteracy rates, poverty, gender biases, discriminatory policies, access to land, funds, extension services and resources or access to key inputs, cultural/religious barrier, herder trespass and conflict, inheritance, lack of storage facilities, low level mechanization, poor post-harvest management, affect women participating in maize production? This paper is an analysis of factors affecting rural women participation in maize production in Jos North LGA, Plateau State. Specifically the study identified perceived labour activities performed by rural women; determined level of rural women participation; and analyzed factors affecting rural women participation in maize production in the study area.

METHODOLOGY

The study was conducted in Jos North Local Government Area of Plateau State, Nigeria. The area is located between latitudes $9^0 82' - 9^0 90'$ North and longitude $9^0 86' - 9^0 90'$ East, with an estimated population of 729, 300 (National Population Census (NPC), 2006). It has a land area of 291 km^2 and is bounded in the north east by Toro LGA in Bauchi State, in the South by Fabur and shere districts of Jos East, on the east by Du and Gyel districts and west by Pengana Irigwe and Rukuba chiefdoms in Bassa LGA of Plateau State Nigeria. The major ethnic group in the study area is the Anaquata's beside other minor settlers like the Igbo, Hausa, Fulani, and Yoruba among others. The main occupation of the people is farming; crops like maize, millet, green pepper, carrot and animal like cattle, load fowl, pigs, goats are reared in the study area. Jos North LGA has one district consisting of 22 communities.

The study covered eleven (11) communities out of the twenty-two (22) in the study area using multi-stage sampling techniques. The first stage was the purposive selection eleven (11) communities based on high level of women participation in maize production activities, while the stage two (2) involved the random selection of 11 respondents from each of the selected 11communities giving a total number of one hundred and twenty-one (121) respondents for the study. Out of the one hundred and twenty-one (121) copies of questionnaire administered; one hundred and eight (108) copies were retrieved and used for analysis. Data for the study were collected using a structured questionnaire, which contained three sections (A, B and C). Section A focused on the labour activities performed by rural; Section B was on level of rural women participation while Section C centered on factors affecting rural women participation in maize production. Data obtained were analyzed using descriptive statistics (mean scores and standard deviation) and inferential statistics (Factor Analysis).

RESULTS AND DISCUSSION

Perceived Labour Activities Performed By Rural Women in Maize Production

Result in Table 1 discloses that women partook in all labour activities involved in maize production in the study area. This agrees with Amah *et al.* (2005) that 60-90% of total farm task especially in maize production such as land clearing, land tilling, planting, weeding, fertilizer application/manure to harvesting, food processing, threshing, winnowing, milling, transportation, marketing as well as management of livestock are performed by women.

Table 1: Perceived labour activities performed by women in maize production in Jos North LGA

Labour Activities	Mean Score ($\bar{x}$)	Standard Deviation
Land clearing	2.34	0.538
Ridge making	2.76	0.489
Planting operations	3.32	1.091
Manual weeding	3.25	0.479
Fertilizer application	3.51	0.878
Supplying	3.66	0.953
Earthening-up	2.99	1.063
Manual harvesting	3.52	0.698
Threshing	3.36	0.728
Winnowing	4.04	1.080
Storage and conservation	3.29	0.794
Marketing	3.06	1.079
General maize processing	3.99	1.816

Source: Field survey 2020 Cut –off mean ($\bar{x} \geq 3.00$)

Level of Rural Women Participation in Maize Production in Jos North LGA

Entries in Table 2 reveal earthening up **($\bar{x} \geq 1.85$)** as the only farm operation below the cut-off mean of ($\bar{x} \geq 2.00$), indicating low level participation of women in it while all other operations recorded high level participation of women (Table 2). This suggests that women engage more in painstaking activities in maize farming and less in tedious and energetic operations. This finding is in line with Olaniyi and Adewale (2012) that in maize production, women usually engage in land clearing, preparation of the land, traditional hoeing and post-harvest operations.

Table 2: Level of rural women participation in maize production in Jos North LGA

Farm Activities	Level of Participation Mean Score ($\bar{x}$)	Standard Deviation
Land clearing	2.34	0.916
Ridge making	2.16	0.893
Planting operations	2.87	0.878
Manual weeding	2.75	1.079
Fertilizer application	2.50	0.549
Supplying	2.46	0.993
Earthening-up	1.85	0.860
Manual harvesting	2.79	0.938
Threshing	2.54	1.063
Winnowing	3.66	0.816
Marketing	2.93	1.051
General maize processing	2.66	1.081

Source: Field survey 2020 Cut –off mean ($\bar{x} \geq 3.00$)

Analysis of Factors Affecting Rural Women Participation in Maize Production in Jos North LGA

Table 3 shows analysis of factors affecting rural women participation in maize production. The analysis reveals five classes of factors as deduced from the respondents' responses. Based on the item loadings, factors 1, 2, 3, 4 and 5 were named processing and storage, soil and climatic, labor and agronomic technologies, institutional and socio-economic, respectively. These represent the major factors affecting rural women participation in maize production in the study area. Factors equal to or greater than 0.50 are said to be significant. Factors which loaded high under Processing and Storage include manual processing (0.767), poor storage facility (0.897) and lack of processing technologies (0569). Storage generates a serious limitation to rural women farmers and storage facility is considered a major challenge to women investment in farming. Agbor and Eteng (2018) identified storage as a major setback to rural women in agricultural production.

Soil and climate factors include climate change (0.579), land inheritance and limitations (0.804), low soil fertility (0.635) and poor crop yield. Poor yield of crops soil fertility reduces the quality of crops produced and thus decreases market value. Land tenure/ limitations constitute a major problem for women contribution to crop food production in Nigeria (Kemi, 2017; Agbor and Eteng, 2018).

Labour and Agronomic technological factors were access to/ key supply of farm inputs (0.647), high cost/lack of seeds (0.816), labour shortage (0.764), lack of planting technology (0.633), poor fertilizer application (0.774), poor knowledge and use of agronomic methods (0.849), weed control (0.530) and unavailability of labour saving technologies (0.732). Rural women in crop production are engaged in wide range of long hours of laborious tasks but lacks labour saving technologies needed for production, processing and storage (Mbah *et al.*, 2017).

Institutional factors comprise discriminatory policies (0.584), gender biases (0.631), poor market information and outlet values (0.510), limited capital and access to credit (0.709). Discrimination against women in agriculture is still common and widespread (Michalopoulos, 2018). Men's control of decision-making and allocation limit women independence and hinder women's progress in a male dominated society.

Socio-economic factors include herder-farmer conflict (0.895), herder trespass (0.529), illiteracy (0.633), land inheritance (0.564), poor extension- farmer contact (0.556) and poverty (0.572). Study by Marechera *et al.* (2022) observed that certain social, cultural and religious orientations of the people in northern Nigeria place restrictions on women, which exclude women from benefiting sufficiently from various programs and interventions that were designed to empower them and guarantee equitable access to productive resources together with men.

Table 3: Analysis of factors affecting rural women participation in maize production in Jos North LGA

Constraints	Factor **1** **(Processing/Storage)**	Factor 2 **(Soil/Climatic)**	Factor 3 **(Labor/Agronomic technology**	Factor 4 **(Institutional)**	Factor **5** **(Socio-economic**
Access to key supply of farm inputs	-0.011	-0.260	**0.647**	-0.317	0.050
Climate change	-0.323	**0.579**	0.214	0.368	-0.188
Discriminating policies	0.216	-0.234	0.012	**0.584**	0.096
Gender biases	0.364	0.355	-0.264	0.434	**0.631**
Herder –farmer conflict	0.566	-0.260	0.060	0.549	**0.895**
Herder trespass	0.356	-0.291	-0.027	0.296	**0.529**
High cost/Lack of seed	0.555	0.193	0.593	**0.816**	0.080
High incidence of pests and diseases	0.027	-0.130	0.223	-0.187	0.029
High rate of illiteracy among women	0.481	-0.168	-0.323	0.296	**0.633**

Labour shortage	0.670	-0.276	**0.764**	0.245	0.564
Lack of information on new variety	0.461	0.053	-0.018	0.012	0.209
Lack of planting technology	0.315	-0.143	**0.663**	0.430	0.581
Lack of processing technology	**0.569**	-0.141	0.564	-0.178	-0.357
Lack of/ Poor storage facility	**0.897**	-0.484	0.341	0.418	-0.011
Land inheritance	0.393	0.804	0.080	0.387	**0.564**
Limited capital/access to credit	0.548	-0.049	0.548	0.289	**0.709**
Low soil fertility	0.455	**0.635**	0.216	0.234	0.012
Poor crop yield	0.336	**0.687**	0.465	-0.215	0.399
Poor extension agent – farmer contact	0.334	0.392	0.068	0.270	**0.556**
Poor fertilizer application	0.459	0.369	**0.774**	0.646	-0.018
Poor use of agronomic practices	0.255	-0.048	**0.849**	0.523	0.047
Poor market information/ outlets/value	0.514	0.050	-0.089	**0.510**	0.393
Poverty	-0.076	0.209	-0.458	0.317	**0.572**
Socio-cultural and religious restrictions	0.565	-0.402	-0.408	0.213	**0.767**
Unavailability of labor saving technology	0.530	0.098	**0.732**	0.483	-0.277
Weed control	0.275	-0.338	**0.530**	-0.019	-0.030

Source: Field survey 2020
Extraction Method: Principal Component Analysis
Rotating Method: Varimax with Kaiser

CONCLUSION

Results of the study show that the respondents were involved in all farming operations with high-level participation in maize production except in energetic undertakings like earthening – up. The study identified five major classes of factors affecting rural women participation in maize production in the study area. The factors include Processing and Storage, Soil and Climatic, Labour and Agronomic Technologies, Institutional, and socio-economic factors. The study recommends that;

i. Efforts should be geared toward the use of scientific and mechanized method of maize cultivation, weed control, harvesting and processing to reduce the drudgery associated with manual labor in maize production practices.
ii. Gender equality should be encouraged to ensure equal ease of access to resources and opportunities to enable women participate actively in maize production.
iii. Women farmers should be trained in good agronomic practices (GAPs) to ensure cost-effective maize production and food sufficiency.

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RESOURCE USE EFFICIENCY OF FLUTED PUMPKIN (*TELFAIRIA OCCIDENTALIS*) PRODUCTION AMONG WOMEN IN CHIKUN LOCAL GOVERNMENT AREA OF KADUNA STATE

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ABSTRACT
The study examined the resource use efficiency of fluted pumpkin production (Telfairia occidentalis) among women in Chikun Local Government area of Kaduna State. Purposive sampling was used to select one hundred women farming fluted pumpkin and they were interviewed using questionnaire. Data collected were analyzed using descriptive statistics, gross margin analysis and multiple regression. The finding revealed that 40.86% of the women fall between the age of 31-40years, 69% of the respondents were married, 70% has a household size of between 6-10 persons,43% of the respondents had primary education, 58% of the women had experience in fluted pumpkin production of between 1-3 years and 59% of the respondents had access to credit. The results indicated that cost of seed, farming experience, and cost of labour were significant at 1% level of probability and influence the profitability of fluted pumpkin among the women in the study area. The efficiency ratio for costs of seed, labour, and chemical showed that these resources were underutilized while the efficiency ratio for fertilizer revealed an efficient use of fertilizer resource. To increase fluted pumpkin production, it is recommended that funds or financial assistance be provided to farmers to produce more fluted pumpkin and enhance economic empowerment, expand their production capacities, policies that tend to reallocate land and inputs, particularly fertilizer and credit, to fluted pumpkin production, and particularly to female farmers, are necessary.
Keywords: *Profitability, fluted pumpkin, production, women, resource use*

INTRODUCTION
Fluted pumpkin is a very important vegetable that is popular in West Africa. It belongs to the family *Telfaria occidentalis* Hook F. cucurbitaceae. For the Igbo people it is the most popular leafy vegetable that produces fruits (Enabulele and Uavbarhe, 2001; Ehiagbonare, 2008). Locally, it is called ugwu'by Igbos in eastern part of Nigeria, Yoruba, Egusiiroko' and Benin, uwmenkhen' (Verla, Sui., Li, Su, Li, and Zhou, (2014). It is called fluted gourd or fluted pumpkin in English (Saalu, Kpela, Benebo, Oyewopo, Anifowope, and Oguntola, 2010). The main use of *T. occidentalis* is as a leaf and seed vegetable. The tender shoots, succulent leaves and immature seeds are cooked and consumed as a vegetable. The leaves are used alone or together with okra (*Albelmos chuscaillei* (A. Chev.) or egusi seeds (*Citrullus lunatus*). They are often cooked with fish, meat, and tapioca. The leaves are rich in iron and are used to cure anaemia. The oily seeds also have lactation promoting properties and are widely consumed by nursing mothers. The plant also contains considerable amount of anti-nutrients such as phytic acid, tannin and saponin which could also have some health benefits (Egbekan, Ada-sulelman and Akinyeye, 2013; Balogun *et al*, 2006). The flesh of the fruit has good oil content which can be used as cooking oil. Although fluted pumpkin is a minor oil crop it possesses healing properties that have been found effective in boosting blood levels and in maintaining bone mineral density in older men when more of the seeds are consumed.
According to Chiebowska (2010), women living in rural areas account for 60 per cent of the world's female population with as much as 70 per cent of them found in less developed countries. Women in large proportion have lived continually in geographically adverse or remote areas and have engaged in unsophisticated agriculture especially in fluted pumpkin production. More specifically, they remain food in-secure farmers (Von Braun, 2005). Some scholars, like Momsen (2004) and Whitehead (2015), posit that the reason for this emanate from inadequate knowledge about the regional differences of these women amidst climate change, soil fertility,

accessibility of credit facilities, family structure, farming systems, among others (Momsen, 2004). Women play vital role towards fluted pumpkin production, producing about 70% of its total production, engaging in land clearing, planting, weeding, harvesting, processing and selling of fluted pumpkin, they believed is an economize and marketable product, because its content the most desirable medicinal value as a vegetable (Schippers, 2004). Despite the high nutritional, medicinal and economic value of *Telfairia occidentalis*, its production in Nigeria has failed to meet the domestic demand for its consumption (Opadode and Adeboye, 2005). It is estimated that over 90% of the total land cultivated in Nigeria is in the hands of men farmers who also account for up to 90% of the total agricultural output (Onokerhoraye, 2015). In Nigeria, the output of fluted pumpkin has not been able to meet the demand for human food not to mention that for livestock feed, because of the growing need of vegetables thus the task of producing enough fluted pumpkin pose an increasing challenge (Ojo, 2002). In most rural communities of Chikun Local Government Area where this study is based, traditional agriculture prevails and farming is seen as a way of life rather than a business venture and often these farmers have no knowledge of advanced management techniques, they do not keep proper farm records and depend mainly on family labour. They are also faced with problems like pest and disease attack, high cost of agro-chemical, poor market structure, poor storage facilities, inadequate credit facilities, bad roads, high cost of hired labour, poor infrastructure/transport and land tenure systems problems.

Fluted pumpkin production is one of the major activities performed by rural women in Nigeria, women believed to be among the major producers of fluted pumpkin, accounting for about 20% of its total production (FAO, 2014). Fluted pumpkin is very important in the diet of children, men, women, nursing mothers as well as livestock due to its high nutritive value. In Chikun Local Government Area, fluted pumpkin plays an important role not only as the major source of vitamins in diets but also as a source of livelihood for most women/farmers who grow and sell this vegetable. But in Nigeria, women need to be giving serious support and attention towards fluted pumpkin production which in turn will provide output that will be able to meet the demand for human food and that of livestock feed as well. As a result of the growing need, the task of producing enough fluted pumpkin by women will increase the total agricultural production in Nigeria and provide job opportunities.

Efficiency of resource use is defined as the ability to derive maximum output per unit of resource, is the key to effectively addressing the challenges of achieving food security Efficiency of resource use is a very fundamental strategy that leads to increase in productivity. Efficient use of farm resources is an important part of agricultural sustainability. One way peasant farmers can achieve sustainability in agricultural production is to raise the productivity of their farms, by improving efficiency in the use of the existing limited resource base and technology (Udoh, 2005). Efficiency of resource use can be assessed from the productivity of the output. This is an important issue of the present time, because resource use efficiency issues are the core elements of sustainable crop production of small-scale farming activities. Efficient use of resources is a prerequisite for optimum farm production since inefficiency in resource use, can distort food availability and security (Etim *et al.*, 2005; Udoh and Akintola, 2001). It is therefore imperative to know whether resources are used efficiently in fluted pumpkin production among the women in the study area. In view of this, this study focuses on resource use of fluted pumpkin production among women in Chikun Local Government Area and prefer solutions that will contribute to the policy formation and implementation that will better the lot of fluted pumpkin farmers and most importantly meeting consumer dietary requirements.

Objectives of the study are to describe the socio-economic characteristics of the respondents in the study area, determine the profitability of fluted pumpkin production among the women in the study area and determine the resource use efficiency in fluted pumpkin production among the women in the study area.

MATERIALS AND METHODS

Study Area: This study was carried out in Chikun Local Government Area (LGA) of Kaduna State. The Local Government Area covers an area of about 445,659km and lies between the latitude and longitude 10^{O}N and 8^{O}E of the equator, (NPC, 2006). Chikun Local Government Area is situated in Northern Guinea Savanna Zone, and shares boundaries with Igabi and Kaduna South Local Government Areas to the North-East and with Kajuru to the East, Birnin Gwari and Giwa local government areas to the North-West and Kachia Local Government Area to the South-East. The ethnic group in the study area comprises of Gbagyi predominantly, Hausa, Kataf, Igbo, Fulani, and Yoruba. Their main occupation is farming, and they plant rice, yam, fluted pumpkin, maize guinea corn, millet and cassava they also reared ruminant animals such as; goat, sheep, and cow, they practice traditional and modern agroforestry system in the area and they are also civil servant and traders.

Sampling Procedure: A multi-stage sampling technique was used for the study. First stage involved the selection of fourteen (14) districts in the Chikun (LGA), The second stage involved a purposive selection of five (5) villages from the fourteen (14) districts which include; Kujama, Chikun village, Sabon Tasha, Gayan and Unguwan Sunday. While the final stage involved a purposive selection of twenty (20) women farmers from each of the villages, to give a total of sample size of hundred (100) respondents respectively.

Method of Data Collection

Primary data was used for this study. The primary data was collected through the use of well-structured questionnaires. This involved the socio-economic characteristics of the respondents (age, sex, marital status etc.), the input and output of fluted pumpkin production, the profitability of fluted pumpkin production in the study area and the constraints facing fluted pumpkin production.

Analytical tools

To achieve the objectives of the study, descriptive and inferential statistics as well as budgeting technique was employed.

Descriptive Statistics

Descriptive statistics such as frequency distribution, percentages were employed. These tools were used to describe the socio-economic characteristics of the respondents, such as marital status, farmers' sex and age distribution, level of education, and household size.

Regression Model

The regression model was used to achieve objective iii stated in the study.

The implicit form of the cost functions is stated as $Q = F(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, U)$ ---------------------(1) where; Q =Total revenue (₦), X_1= Age (Years), X_2 = Farm size (ha), X_3= Cost of seed (₦), X_4= Household size (number of person)X_5= Farming experience (Years), X_6=Cost of Labor (₦), X_7=Cost of fertilizer (₦), X_8=Cost of chemical(₦), U=Error term, B_0= constant term and B_1 to B_8= coefficient of the independent variables stated above.

Economic Efficiency of Resource use

The following ratio was used to estimate relative efficiency of resource use (r).

$r = \frac{\text{MVP}}{\text{MFC}}$……………………………………………………………………… (2)

Where:

r = efficiency ratio, MFC = Cost of one unit of a particular resource and MVP = value added to vegetable output due to the use of an additional unit of input calculated by multiplying the MPP by the price of output i.e.

X_{i} = various input used

MPP_{Xi} x P_q……………………………………………………………... (3)

MPP_{Xi}= dy = b $\overline{Y}$ /$\overline{xi}$……………………………………………………………………… (4)

Where,

$\overline{Y}$ = mean value Y output

$\overline{x}$ = mean value x input

Where linear equation is the lead equation

$MPP_{Xi} = \frac{dy}{dx} = \frac{bi}{xi}$ ………………………………………………………………….. (5)

(Direct elasticity from the double log form)

Decision rule

If r = 1 Resource is efficiently utilized, r = >1 Resource is under-utilized and r = <1 Resource is over-utilized

Economic optimum takes places where MVP-MFC if r ¹1, it suggests that resources are not efficiently utilized. Adjustments could therefore be made in the quantity of inputs used and costs in the production process to restore r = 1.

RESULTS AND DISCUSSION

Socio-economic Characteristics

The results from the table 1 shows the age distribution of the sample producer 6.45% are within the age of 21-30 years, 40.86% are within the age of 31-40 which is the highest range, 32.56% are within the age 0f 41-50 years, 12.90% are within the age of 51-60 years and 7.53 are within the age of 61-70 years. The table below revealed that (65.50%) of the farmers were aged between 31-50 years. This implies that at least two thirds of the women farmers were still economically active and in their productive stage. This is According to Emenyonu *et al* (2010). From the table below, it was discovered that majority of the women were married with 68.82%, and 26.88% was widow, 3.23% were single, while 1.08% were divorced. It means married women are actively involved in the production of Fluted pumpkin. From the table below, it was revealed that 24.73% of the women farmers had between 1-5 family size, 68.82% was the highest with the family size of 6-10 while 5.38% was the least with family size of 11-15 persons. This is an indication that a large family is still a common practice among farmers as they often depend on family labour. According to Ahmed (2006) household size to a very large extent determines the income level to household. This could also be a strategy to assist in family upkeep. The level of education of farmers increases their farm production and enhances the ability to understand and evaluate new technology. Table 4 below shows that the respondents have varying degree of educational background ranging from non-formal education to post-secondary education. The result show that 27.96% of the farmers have non-formal education, 43.01 have primary education and 29.03% respondents have post-secondary education a positive correction between level of education and adoption of innovations and formal education had a positive influence on adoption of innovation Nasiru *et al,* (2005) stressed that attendance to formal education is a prerequisite for getting a secure or a regular employment which leads to a more stable income from which marginal propensity to save increase. Table 1 shows that 58.1% of respondents had 1-3 years of experience in fluted pumpkin production, 31.3% has 4-6 years of experience while 9.8% has 7-9 years of experience and about 1.1% has I years farming experience. According to Asogwa (2005) years of farming experience is one of the variables that significantly influence efficiency among farmers in Nigeria. The results also show that the farmers are experienced and knowledgeable in Fluted pumpkin production. Table 1 below shows that 59.2% of the fluted pumpkin farmers has access to credit while 40.9% of the respondents has no access to credit. This implies that, access to credit by fluted pumpkin farmers is poor in the study area.

Table 1: Socio economic characteristics of the respondents

Age group	Frequency	Percentage	Mean
21-30	6	6.45	
31-40	38	40.86	
41-50	30	32.56	44.05
51-60	12	12.90	
61-70	7	7.53	
Marital status			
Single	3	3.23	
Married	64	68.82	
Widow	25	26.88	
Divorced	1	1.08	
Family size			
1-5	23	24.73	
6-10	56	69.9	6.08
11-15	5	5.38	
Educational background			
Non-formal education	26	27.96	
Primary education	40	43.01	
Post-secondary education	27	29.03	
Experience			
1-3	54	58.1	
4-6	29	31.3	3.80
7-9	9	9.8	
> 10	1	1.1	
Access to credit			
Yes	55	59.2	
No	38	40.9	
Total	**93**	**100**	

Determinants of profitability

The result in table 2 shows that the multiple regression analysis estimate of profitability of Fluted pumpkin among women in Chikun Local Government Area was done in four function forms (linear, semi log, double log, and exponential forms). The result of the analysis showed that the linear function had the best fit and was therefore chosen as the lead equation. R^2 of 0.4806. This implies that 48% variability in profitability was explained by the explanatory variables while the remaining 52% was due to error term. The coefficient of cost of seed (X_1) significant at 1% has a positive relationship with Fluted pumpkin production. This implies that the more seed, used for production, the increase in the women production in Fluted pumpkin the efficient of farming experience X_5 has a direct relationship with output of the women farmers and significant at 1%. The more experienced a farmer the higher his production. The cost of labour (X_6) was also positive and significant at 1% level of probability. The results indicated that quality of cost of seed (X_3), farming experience (X_5) and cost of labour (X_6) are significant and influence the profitability of fluted pumpkin production among women in the study area. That is 05702, 4710.822 and 1.3973unit increase in each of X_3, X_5, and X_6 will bring about one unit increase respectively in the output.

Table 2: Estimate of Production Function of Fluted Pumpkin Women Farmer in Chikun Local Government Area of Kaduna State

Variable	Coefficient	t-value	Standard error	Significance
Age (X_1)	-468.6298	-0.37	1250.66	0.709
Farm size (X_2)	-9652.21	-0.25	38968.82	0.850
Cost of seed (X_3)	2.360424	4.14	0.5702326	0.000*
Household size (X_4)	536.4258	0.08	6669.561	0.936
Farming experience (X_5)	13773.84	2.92	4710.822	0.004*

Cost of labour (X_6)	3.275747	2.34	1.397313	0.021*
Cost of fertilizer (X_7)	7.023853	1.18	5.971561	0.243
Cost of chemicals (X_8)	-7.531185	-1.36	5.54558	0.178
Constant	50933.19	0.77	66349.57	0.445
R^2 = 0.4806				
Adjusted R^2 = 0.52				
F – Statistically = 9.71				
Observation = 93				

,* at 1%, 5% and 10% level of significance

Determination of resource use efficiency

The concept of efficiency indicates the maximum benefits derived from allocation and use of resources. The result in table 3 showed that the ratio of the marginal value product (MVP) to Marginal factor cost (MFC) was; 0.1023, 0.1256 and -6.6019 for cost of seed (X_3), cost of labour(X6) and cost of chemical(X8). Cost of seed, cost of labour and cost of chemical were less than 1 which implies that farmers are still facing problems of inefficiency of resource allocation in the study area. while fertilizer was 1 for fertilizer (X_7) and equal to 1, it implies the efficient utilization of this resource due to availability of fertilizer to carry out farming.

Table 3: Determination of resource use efficiency

Variables	B	Y	X	MVP	MFC	MVP/MFC	Efficiency
Seed	2.360424	202752.6	10580.11	10.231	100	0.1023	Underutilized
Labour	3.275747	202752.6	46779.57	62.775	500	0.1256	Underutilized
Fertilizer	7.023853	202752.6	8462.37	168.27	220	1	Efficiently utilized
Chemical	-7.531185	202752.6	1927.42	-792.233	120	-6.6019	Underutilized

CONCLUSION AND RECOMMENDATIONS

In conclusion, majority of fluted pumpkin women farmers are married, young, educated, experienced and small-scale female farmers producing mainly for household consumption on part time basis. Seed, labour and chemical which are major predictors of production. All these variables must be considered when designing a technological package for this resource and should be further exploited to improve productivity level of the women farmers in the study area.

Based on the findings the following recommendation were made.

i. To increase Fluted pumpkin production, fund or financial assistance should be provided to the farmers in other to produce more Fluted pumpkin and enhance economic empowerment, expand their production capacities.

ii. Policies that tend to reallocate land and inputs especially fertilizer and credit to fluted pumpkin production and particularly to the female farmers are necessary. Such policies should be targeted more at experienced farmers with large household sizes, and small farm size. They should seek to improve the functioning of credit disbursement mechanisms especially through functional cooperative societies.

iii. The various problems and constraints limiting production could be reduced or avoided if the government harness resources towards rural infrastructural development of the communities, empowerment of the farmers through capacity building on integrated pest management, improved cultural practices to reduce their cost of production.

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GENDER DIFFERENTIALS OF POVERTY AMONG RICE FARMING HOUSEHOLDS IN NIGER STATE, NIGERIA

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ABSTRACT

The study aimed at examining the gender differentials in poverty among rice farming households in Niger State. Multi stage sampling technique was used to select 130 male and 106 female household heads involved in rice farming. A well-structured questionnaire and interview schedule was used to obtain information on socio economic characteristics and other quantitative variables of interest for the study. Data collected were analysed using Foster-Greer-Thorbecke (FGT) model, and Oaxaca-Blinder (OB) Decomposition. Poverty incidence, poverty depth, and poverty severity of 0.27, 0.5, and 0.25 respectively were higher than that of male headed households with 0.14, 0.1262 and 0.0159 respectively. The major cause of differential in poverty is caused by endowment effect which was in favour of male farmers. Based on these, the study concluded poverty is higher among female headed households. The poverty differential was in favour of male farmers. It was recommended that government and traditional institutions should promote equality through the removal of all forms of barriers and limitations which reduces the productivity of the females. Rice farmers especially women need to adopt smart innovative production technologies to enhance productivity and consequently reduce poverty. Farmers should be encouraged to further engage in non-agricultural activities due to the seasonal nature of rice farming in Nigeria.
Key words: *Rice farming, Gender, Differentials, Poverty, Households*.

INTRODUCTION

Rice is a food crop widely produced and consumed globally, rice alongside maize and wheat provide at least 42% of the world caloric intake, it can also be said that rice serves as staple food to more than 3.5 billion people which is more than half of the world's population (Lanessa, 2017). Although rice is an important crop for household food consumption and combating poverty, production has not kept pace with demand and not being gender sensitive in policy making characterised Nigeria situation **(**Ajewole *et al.,* 2016**).** Nigeria's extreme poverty rate is high and increasing. Despite its middle-income status, almost four out of 10 Nigerians lived below the national poverty line in 2016. Measured at international poverty line of US$ 1.90 per day, Nigeria is home to the largest number of extremely poor people, overtaking India in 2018. The increase in poverty rate observed in Nigeria is higher when compared with neighboring countries. The poverty rate increased from 35.0 to 38.8 percent of the total population from 2011 to 2016 (World Bank, 2019).

It is common knowledge that gender inequality is one of those issues encountered as it cut across different roles, norms, and values, govern the gender division of labour and gender distribution of resources, responsibilities, agency and power (Edeoghon, 2019). Though many studies on gender differentials have been conducted in Nigeria, the focus has being on productivity (Idumah *et al.,* 2015, Agada *et al.,* (2018), Bassey *et al.* (2019) and Ahmed and Deji (2020). Only very few (Ajewole *et al.(*2016), Buba *et al.* (2018); has been done on poverty in different parts of Nigeria, little is known to the researchers in the study area. Therefore, there is a need for more research in the area of gender differential in poverty.

This study tends to achieve these objectives;

I. Analyse the poverty status of farmers in the study area; and
II. Decomposition of gender differentials of poverty in the study area

METHODOLOGY

The study was conducted in Niger State, Nigeria and the State was created in 1976. It is located in Guinea Savannah Region and lies between latitude 80^0 to 11^0 30'North and longitude 03^0 30' to 07^0 40' East of the equator. Multistage sampling technique was used for this study. In the first stage, one Local Government Area was purposively selected from zone namely: Lavun, Paikoro and Wushishi. In the second stage, random sampling was used to select two communities from each Local Government Area. The third stage involves the stratified random selection of male and female headed households. A total of 236 farmers were selected for this study. Yamane, (1973) formula was used to estimate the sample size from the sampling frame. Foster Greer and Thorbecke (FGT) index model was used to analyse poverty status of respondents while Oaxaca-Blinder (OB) threefold for decomposition of the gender differences in poverty.

Model specification

Foster-Greer-Thorbecke (FGT)

Poverty Index was used to evaluate the poverty status of rural household and to disaggregate them into poor and non-poor categories. It has become customary to use the Pα measures in analyzing poverty. The measures relates to different dimensions of the incidence of poverty P0, P1 and P2 was used for head count (incidence) depth and severity of poverty respectively. The mathematical formulation of poverty measurements as derived from Foster, Greer and Thorbecke (1984) is estimated as:

$$P_{ai} = \frac{1}{n}\sum_{i-1}^{q}\left[{(z-y)}/{z}\right]^{\alpha} \qquad (1)$$

Where:

α = degree of poverty

n = number of households in a group

q = the number of poor households

y= the per capita Income (PCI) of the i^{th} household.

z = poverty line

α values of 1, 2, 3 were used in measuring poverty incidence or head count, poverty depth and poverty severity respectively

Oaxaca-Blinder (OB) Decomposition

Oaxaca-Blinder decomposition approach for non-linear regression by Bauer and Sinning (2008) was used to breakdown the poverty disparity as follows:

$E(P_m) – E(P_f)= [E(X_m) – E(X_f)]\beta_f + E(X_f)(\beta_m - \beta_f) + [E(X_m) – E(X_f)](\beta_m - \beta_f)$ (3.8)

$E(P_m) – E(P_f)$ = mean difference in poverty between male headed and female headed household

$E(X_m) – E(X_f)$ = expected variable factors of male and female that contribute to differences in poverty.

$\beta_{m.}$ and β_f estimated parameters for male and female

RESULTS AND DISCUSSION

Poverty status of the Respondents

The poverty status of the respondents was analysed using Foster-Greer-Thorbecke (FGT) model. The result is as presented in Table 1. Findings revealed the head count incidence of poverty for male and female household heads was 0.14 and 0.27 respectively. This means that 14% of the male household heads and 27% of the female household heads were poor or had per capital income below the poverty line. The result shows that female household heads were poorer than male household heads. This result is in agreement with the findings of Oluwatayo (2014), Edet and Etim (2014).

Table 1: Distribution of respondents based on Poverty status and indices

	Male		Female	
Indices	Freq.	%	Freq.	**%**
Poor	18	13.85	29	27.36
Non poor	112	86.15	77	72.64
Poverty line	₦ 30,570.42		₦ 27,229.59	
Poverty Incidence	0.1385		0.2736	
Poverty gap index	0.1262		0.5	
Poverty Severity index	0.0159		0.25	

Source: Field Survey, 2021

Note: Freq implies frequency, % implies percentage.

The higher poverty observed in women rice farmers could be attributed to social norms and limitations of women from equal access to productive resources like men, other reasons may be large household size, restrictions in use of farm land for farming activities and higher dependency on farming as only means of livelihood. However, the result disagrees with the findings of Eduomiekumo *et al.*, (2014) and Ajewole *et al.* (2016) who reported that male headed households were poorer than female headed households. More so, the poverty gap for male headed households and female household heads was 0.1262 and 0.5 respectively, this finding imply 12.62% and 50% of the per capita income are required to raise poor male and female household heads from below the poverty line to the poverty line.

Decomposition of Gender Differentials in Poverty

Table 2 provides the result of the threefold Oaxaca-Blinder decomposition of the gender differential in poverty among the rice farming households, it summarizes main findings by grouping covariates (see Table 2) the first panel of the decomposition presented in table 2 reveals the mean gender estimates for poverty levels by groupings and their variations. It reveals a poverty differential gap of 0.2548, the poverty prediction level by groups and differential gap was significant at 1% level of probability. This finding is in line with findings of Mukasa and Salami (2015) and Morgrado and Salvucci (2016).

The decomposition result of second panel is divided into three parts. The endowment effect, which represents the first component, indicates the rise in poverty of the rice farming households if the male and female household heads had the same endowment. The second part is the coefficient effect which quantifies changes in the female poverty when applying the male coefficients to current level of female characteristics. The third component is the interaction term, which calculates the joint impact of variations in endowments and household head coefficients. According to the decomposition analysis, there are gender disparities of -0.1632551(64.06%) due to endowment, -0.1401766(55.00%) due to coefficients and 0.0485697 (-19.05%) due to interaction of endowment and coefficient effect. Accordingly, the part due to endowment effect was positive and significant at 1% probability level. Also, the part due to coefficient effect was positive and significant at 5% probability level. Consequently, the coefficient for interaction was positive but not significant. This implies that the major cause of differential in poverty is caused by endowment effect, it also implies the male farmers have more endowment benefit and have more structural advantage (coefficient effect) in comparison to the female farmers.

In panel 3, a detailed breakdown of the endowment effect, structural effect, and interaction effect is presented. The endowment effect is mostly explained by differences in household size which was positive and significant at 1%. This suggests that the size of the household tends to have a greater impact on households headed by male farmers. None of the variables had a coefficient effect (structural) that was significant. However, the majority of the variables' magnitudes had a positive sign. Household size, Education, cooperative membership, access to credit, land ownership, household income, household expenditure and remittance were all positive but not significant. Also, the constant was positive but not significant. This suggests that, compared to their female counterparts, male farmers gain more from the return to observable characteristics.

Furthermore, none of the variables had any significance in the interaction impact. However, the majority of the variables' magnitudes had a negative sign. Hence, for poverty to be reduced, policy creation and interventions should be focused on integration, granting women access to resources and opportunities for engagement of women in policy formulation and execution, as well as effective monitoring of programmes aimed for their welfare. This is consistent with findings of Aguilar *et al*. (2014) Mukasa and Salami (2015) and Lubrano (2016).

Table 2: Oaxaca-Blinder three fold decomposition of gender differentials in poverty among rice farming households

1	**Gender differentials**								
Category	**Coefficient**	**Std. error**	**Z-value**						
Male	0.7076	0.0406	17.40***						
Female	0.4258	0.0500	9.05***						
Difference	0.2548	0.0645	3.95***						
2	**Aggregate decomposition**								
	Endowment effect(E)			**Coefficient effect(C)**			**Interaction effect(EC)**		
	Coeff.	**Std. error**	**Z-value**	**Coefficient**	**Std. error**	**Z-value**	**Coeff.**	**Std.error**	**Z-value**
	-0.1633	0.0553	-2.95***	-0.1402	0.0661	-2.12**	0.0486	0.0582	0.84
% share of the differentials gap	64.06%			55.00%			-19.05%		
3	**Detailed decomposition**								
Variables	**Coeff.**	**Std. error**	**Z-value**	**Coeff.**	**Std. error**	**Z-value**	**Coeff.**	**Std. error**	**Z-value**
Age	-0.0062	0.0155	0.40	-0.1365	0.3107	-0.44	-0.0141	0.0323	-0.43

Marital status	-0.0024	0.0060	0.40	-0.1022	0.0955	-1.07	0.0105	0.1184	0.89
Farm Size	-0.0055	0.0102	0.54	-0.0244	0.1316	-0.19	0.0036	0.0195	-0.19
Farming experience	0.0095	0.0106	0.90	-0.0547	0.1503	-0.36	-0.0045	0.0130	-0.35
Education	0.0027	0.0055	0.50	0.0404	0.10667	0.38	0.0012	0.0039	0.31
Household Size	0.0269	0.0217	1.24	0.1944	0.1425	1.36	0.0132	0.0141	0.93
Cooperative Membership	0.0021	0.0062	0.34	0.0228	0.0748	0.31	0.0007	0.0028	0.23
Extension	0.0020	0.0091	0.22	0.0359	0.0501	-0.72	-0.0009	0.0044	0.21
Access to credit	0.0158	0.0191	0.83	0.0515	0.0646	0.80	-0.0043	0.0075	-0.58
Occupation	0.0121	0.0080	1.51	0.2735	0.1805	-1.52	-0.0266	0.0206	-1.29
Land ownership	0.0021	0.0084	0.25	0.0054	0.0645	0.08	-0.0013	0.0156	-0.08
Household income	0.0876	0.0305	2.87***	0.1103	0.1621	0.68	-0.0175	0.0263	-0.67
Household expenditure	0.0057	0.0065	0.89	0.0305	0.0485	0.63	0.0041	0.0076	0.54
Remittance	0.0150	0.0109	1.38	0.0231	0.0678	0.34	-0.0144	0.0425	-0.34
Constant				0.2889	0.4145	0.70			

Source: Field survey, 2021

CONCLUSION AND RECOMMENDATION

Based on the study it can be concluded that poverty incidence was higher among female headed households in comparison to the male headed households. Furthermore, the study revealed the poverty differential was largely due to differential in endowment effect which was in favour of the male headed households.

From the findings of the study the following recommendation were made.

(i) Women should be given equal access to production inputs such as land, fertilizer, use of modern farm tools and machines as this would increase the productivity of the female household heads as most times women are marginalized in the use of farm inputs;

(ii) Rice farmers especially women need to adopt smart innovative production technologies to enhance productivity and reduction in poverty.

(iii) Farmers should be encouraged to further engage in non-agricultural activities, the seasonal nature of rice farming in Nigeria limits the earning potential of farming as a source of livelihood. More engagement in non-agricultural activities would complement in areas of earning deficiency.

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DETERMINANTS OF POVERTY STATUS AMONG WOMEN FARMERS IN DEVELOPMENT EXCHANGE CENTRE (DEC) MICROCREDIT OF KADUNA STATE, NIGERIA

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ABSTRACT
This study was conducted to determine the poverty status of women farmers in Development Exchange Centre Microcredit of Kaduna state, Nigeria. The study utilized primary data collected through questionnaires administered to 420 respondents (210 DEC participants and 210 non-participants) were selected using purposive and random sampling procedures. Data were analyzed using simple descriptive statistics, the FGT poverty model and Logit regression model. The result of the FGT poverty model revealed that the incidence of poverty among the farming households was 40% and 50% of participants and non-participants. Implying that 60% and 50% of the respondents' farm households were not poor. The result of the Logit regression showed that age, education, farm size, farm experience, income, crop output, level of living and access to DEC microcredit were significantly related to the poverty level of the women farmers. This implies that a unit increase in these variables will likely lower household's head of being poor. It is therefore recommended that amount of credit facilities provided should be increased so as to increase productivity, time for repayment of credit facilities should be extended to more than one year and the programme should be extended to other farming communities in the State, so as to accelerate the reduction of poverty among rural women in the state and nation at large.
Keywords: *Determinants, poverty status, women farmers, development exchange centre, microcredit*

INTRODUCTION
Poverty is a problem affecting every nation of the world (Chen and Ravallion, 2016). Poverty has been aptly summarized in both absolute and relative terms, as a state where an individual is not able to cater adequately for his/her basic needs of food, clothing and shelter; meet social and economic obligations, lacks gainful employments, skills, assets and self-esteem and has limited access to social and economic infrastructure. In other words, "the poor lacks basic infrastructure, such as education, health, potable water, and sanitation, and as a result has limited chance of advancing his/her welfare due to limited access to social and economic infrastructures (Adamu and Michael, 2019). Many people all over the world live in absolute poverty and suffer from chronic hunger. Statistics shows that about 3.1 billion people (55%) in rural areas are poor women with about 1.4 billion living in less than US $1.25 (₦197.50) a day while 70% of these very poor people rely on farming and agricultural labour (Simpa,2014; World Bank, 2016. Women poverty status has received increased attention of the economists and policy makers since 1990 after the Fourth World Conference on women at Beijing, 1995 (World Bank, 2007). Efforts to reduce poverty was further intensified by world leaders after the World vision 2020 African Conference held in Uganda in 2003 and it was also the first of target among the agenda of Millennium Development Goals (MDGs) with the aim of reducing extreme poverty and hunger by half in year 2015 (Vincent, 2006; Simpa, 2014). Poverty reduction is a priority task facing Nigerian government and Non-governmental organization. The incidence, depth, and severity of poverty among women farmers are such that poverty reduction strategies are synonymous with economic growth and development strategies.

Development exchange centre microcredit programme (DEC) is a non-governmental organization who is concerned about worsening rural poverty and the marginalization of women. Its main objectives includes efforts to strengthen access to credit, participation in decision-making, access to agricultural extension services, access to improved farm inputs and tools, traditional thrift and savings. DEC is committed to strengthening rural financial services and improved access to credit, as a key to reducing poverty among women farmers (DEC Newsletter, 2014). Since poverty is a major constraining factor among women farmers (Olawuyi and Adetunji, 2013), it is still important to investigate how socio-economic factors and other related variables that determine poverty among women farmers in rural areas in Nigeria. This study looks at poverty as lack of necessities based on individual's perspective and status. Identifying the determinants of poverty in rural areas is very crucial to understanding the causes of poverty, and for formulating policies directed at its reduction. Therefore, the broad objective of this study is to assess the determinants of poverty among women farmers DEC microcredit participants in Kaduna State, Nigeria, while the specific objectives are to: identify socio-economic characteristics of the women farmers DEC microcredit participants in the study area.; and, Determine the poverty status of the women farmers DEC microcredit participants' in the study area

METHODOLOGY

The study was conducted in three local governments' areas (LGAs) of Kaduna State. The LGAs are Sabon-Gari in the northern, Kaduna-South in the central and Jema'a in the southern Senatorial District of the state. These LGAs were randomly selected out of nine LGAs participating in DEC microcredit programme in the State. Kaduna State is in north-western Nigeria, located between Latitudes 9° and 12°N and Longitudes 6° and 9°E of Greenwich Meridian. It shares boundaries with Abuja in the east and Katsina, Kano and Zamfara in the north, Nasarawa and Plateau in the northeast and Niger in the northwest. The mean annual rainfall is between 1500mm and 2000mm in north and south respectively. Kaduna State has an estimated population of 6,066,562 (NPC, 2006) out of which the female population is 2,954,534(48.7%) (National Commission for Mass Literacy Adult and Non-formal Education, 2008). It is estimated that the population has increased to 8,578,657 by 2017 based on the National Population Commission (NPC) annual growth rate of 3.2%. while the female population will be 4,177,947 at the same growth rate. The state covers an area of about 45,786 km^2, (Federal Office of Statistics, 2006).

Multistage sampling technique was used for this study. In the first stage, three Local Government Areas (Sabon-gari, Kaduna south and Jema'a) were randomly selected from the nine LGAs participating in DEC microcredit programme in the state. In the second stage, two villages each were randomly selected from each of the three LGAs. In the third stage, from a sample frame of 2,103 women participating in the DEC programme, 210 participants, representing 10% were randomly selected. The list of participating women was obtained from the DEC microcredit office in Kaduna. Finally, the list of two hundred and ten (210) non-participant women farmers was also obtained from Kaduna Agricultural Development Project (KADP) extension agent. This was randomly selected to obtain a total sample size of 420 respondents. Primary data were used for this study. The data were collected from the respondents with the aid of a structured questionnaire. Analysis of data collected from the field was done using mean, percentages and frequency, Foster-Greer-Thorbecke (FGT) poverty model and Logit regression model.

RESULTS AND DISCUSION

Socioeconomic characteristics of respondents

Table1 shows that majority (45%) of respondents were between the age of 31 to 40 years for participants and about 50.4% for non-participants. Mean age of participants was 37years while non-participants were 38 years. About 72% and 69% of participants and non-participants respectively, had one form of education or another. 60% of participants and 47 % non- participants had a mean of 6 persons per household. 71% of participants and 62 % non- participants cultivated land areas of between 2 to 4 hectares while approximately 22% of non-participants cultivated less than 2 hectares. The mean farm size for participants and non-participants was 2 hectares. Majority of the cropping season in the study area. The result in Table 1 shows that, 71% of programme participants received between ₦40, 001 – ₦50 with a mean amount of ₦45, 580.95.

Table 1: Distribution of respondents according to socioeconomic characteristics

Variables	Participants	Mean	Non-Participants	Mean
Age(years)				
20-30	39(18.7)	**37**	45(21.4)	**38**
31-40	94(44.9)		106(50.4)	
>50	77(36.7)		5928.3)	
Education level (years)				
Primary education	51(24.3)		32(15.2)	
Secondary educ.	92(43.8)		100(47.2)	
Tertiary education	08(3.8)		13(6.2)	
Koranic education	59(28.0)		65(30.9)	
Household size (no.)				
1-3	62(29.5)	**6**	99(47.1)	**6**

4-6	126(60.0)		99(47.1)	
>7	22(10.4)		12(5.7)	
Farm size(ha)				
< 2	25(11.9)	**2.0**	46(21.9)	**2.0**
2.0- 4.0	149(70.9)		130(61.9)	
>4	36(17.2)		34(19)	
Farming Exp (years)				
1-10	09(4.3)	**22**	13(6.2)	**19**
11-20	109(51.9)		140(66.7)	
21-30	79(37.6)		52(24.8)	
>40	13(6.2)		5(2.4)	
Credit received (₦)				
20,001-40,000	53(25.2)	₦45,580.95		
40,001-50,000	150(71.4)			
>50,000	7(3.4)			

Source: Field survey, 2015 Figures in parentheses are percentages

Poverty status of the farmers in the study area

Determination of poverty line

The result in Table 2 give estimation of the poverty line that was used to determine the poverty status of DEC microcredit participants and non-participants in the study area. The poverty line formed the basis for further analysis. The Foster-Greer-Thorbecke (FGT) class of poverty measures was employed to estimate the poverty status of the respondents. The result showed household food and non-food expenditure, total expenditure, per capita and mean per capita expenditure and the poverty line. The poverty line was constructed as two-thirds of the mean per capita household expenditure (MPCHE) of all households. This approach has been used by several researchers and institutions (NBS, 2012; Oni and Yusuf, 2008) as a measure of welfare. Households were then classified into their poverty status based on the poverty line. Hence, non-poor households were those whose per capita expenditure was above or equal to two-third of the mean per capita expenditure of all households while those whose per capita expenditure was below two-thirds of the mean per capita expenditure were classified as poor. Based on this, the poverty line constructed as two-third of the mean per-capita expenditure for participants and non-participants households was ₦159,880 (monthly). This implies that households whose monthly per capita expenditure fell below ₦159,880 were classified as poor while households whose per capita expenditure equaled or was above the poverty line were classified as non- poor.

Table 2: Determination of participants' and non-participants poverty line

Type of expenditure	Participants	Non-participants
Household food expenditure	230,283.71	152,766.37
Household non-food expenditure	184,729.51	71,300.94
Household total expenditure	415,013.22	224,067.31
Per capita household expenditure (PCHE)	104,033.47	66,717.23
Mean Per capita household expenditure (MPCHE)	2,092.23	1,187.41
2/3 MPCHE (Poverty line)	159,880	159,880

Source: Field survey, 2015

Effect of DEC microcredit on poverty status of the programme participants

The Logit regression model was used to estimate the determinants of poverty status of the women DEC participants with particular interest on the influence of DEC microcredit on their poverty level. Entries in Table 3 shows the likelihood ratio Chi-square was significant (p<0.01) with Chi-square value of 201.40, which means the model is a good fit. Age, education, farm size, farm experience, credit, income crops output and level of living. Household size, indicates that age has a positive coefficient (0.054) and is significant at P<0.05 level of probability. This implies the age of farmer will significantly influence his or her poverty status. The age of the respondents were found to be positively correlated to their poverty status, indicating that as a household head got older, the livelihood of being poor increased. This position is consistent with that of Gang *et al.* (2002), and Garza-Rodriguez (2021) that poverty increases with old age, as the productivity of the individual decreases.

The coefficient of education was also significant (p<0.05). This implies that a year increase in years of schooling will decrease the probability of been poor among participant households. This may be attributed to the fact that educated household heads tend to adopt improved farming techniques better and faster than uneducated ones. This raises the productivity and income of the educated heads and subsequently alleviating poverty among their households. Farm size had a positive coefficient (0.435) and was significant at P<0.01 level of probability. This implies that farm size is an important poverty status determinant in the study area and significantly influences the probability that a household would be poor or non-poor. The coefficient of farm experience was found to have a direct relationship with the poverty status of programme participants in the study area and is statistically significant at 1% level of probability. This implies that farm experience is an important determinant of poverty status in the study area and significantly influences the probability that a household would be poor or non-poor. Moreover, Farm inputs was important factors in farm productivity among participants' households but was insignificant in determining poverty. Although labour was an important asset in farm productivity with a positive coefficient (0.012), it was also not a significant variable in poverty status determination among participants' households. Access to market also had positive coefficient (0.006), but was insignificant variable in determining poverty status. Credit assists the farm households in the purchase of farm inputs such as fertilizers, herbicides, improved seeds and investment demand to increase productivity. The coefficient of access to credit was significant at 5% level and negatively related to the poverty status of the farm households. This implies that access to credit in the study area reduces the likelihood of a women DEC participant's household being poor and this is because access to DEC credit gives the women farmers the opportunity of enhancing their production capacity through purchase inputs such as improved seeds and fertilizer. This is not surprising, as credit can reduce liquidity constraints and increase the capacity of households to start off-farm businesses. This is in line with the findings of Babatunde and Qaim (2009) who reported that access to credit has a positive influence on income of women households. Farm income had a positive coefficient (26.562) and was significant at P< 0.01 level of probability. This implies that farm income is an important variable in poverty status determination and that it significantly influenced the probability that a household was poor or non-poor. Increased income enables the households to move out of poverty. Crop output had a positive coefficient (0.375) and was significant at P<0.010 level of probability. Crop output is a variable in poverty status determination. Therefore, a unit increase in the crop output increased the probability of the farming households moving out of poverty by 99.9%. Living standard of the households was found to be positive and significant at P<0.01 level of probability. Thus a unit increase in the households' living standard increased the probability of households escaping from poverty by 0.6%. The model accounted R^2 (0.693) for 69% of the variation in poverty status of DEC microcredit programme participating households.

Table 3: Result of the factors influencing poverty status of respondents

	Participants			Non-participants		
Variables	Coefficient	S E.	Z-value	Coefficient	S E.	Z-value
Age	0.054	0.014	3.857***	1.961	0.689	2.846***
Education	0.414	0.169	2.449**	0.08	0.099	0.808
Farm size	0.435	0.052	8.365***	0.014	0.010	1.40
Farm Experience	1.440	0.342	4.210***	-0.050	0.054	-0.925
Farm inputs	0.014	0.040	0.350	-0.004	0.073	-0.054
Labour	0.012	0.010	1.200	0.919	0.107	8.588***
Access to market	0.006	0.023	0.260	0.504	0.1172	4.300***
Credit	-1.00011	0.0000	6.810***	-0.263	0.397	-0.662
Income	26.562	9.718	2.733***	0.718	0.864	0.831
Crops output	0.375	0.199	1.884*	7.363	28.575	0.257
Level of living	0.006	0.0017	3..529***	2.031	1.0311	1.969*
Constant	1441.	8024.3	0.179	1.963	0.693	2.832***
Number of observation = 210				210		
Pseudo R^2 = 0.693				0.753		
Chi-square 71.34***				201.40		
P-value = 0.000				0.000		

Source: Field survey, 2015 *** P< 0.01, ** P<0.05 and * P<0.10

CONCLUSION

Based on the findings of this study, it can be concluded that 4% and 48% of the participants and non-participants' farm households were poor, implying that 96% and 52% of participants and non-participants of the farmers households were non-poor. Age, farm size, farm experience, income, crop output, access to DEC credit and standard of living, significantly determined the poverty status of farming households in the study area. Access to DEC microcredit by the farm households decreased the farm households' probability of being poor implying that access to DEC microcredit offers an opportunity for alleviating poverty among the farm households in the study area. Therefore, it is recommended that the programme should be replicated in other communities in the state to achieve poverty reduction among the women folks in the state and nation at large.

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FARMING SYSTEM AND LIVELIHOOD ACTIVITIES AMONG CASSAVA FARMERS IN IMO STATE: A GENDER SITUATION ANALYSIS

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ABSTRACT
An investigation into the gender analysis of the cassava cultivation system and the rural farmers' livelihood activities was carried out in the Imo state. Four communities that are prominent in cassava production were selected from three agricultural zones of the state. The respondents' responses were elicited using a mixed method that included individual interviews, key informant interviews, focus groups, and market interviews. Transcribing discussant responses allowed for data analysis. The findings from the focus group discussions reveal that Imo State's male and female farmers almost always practice intercropping cassava with other crops because it increases crop yields and makes weeding easier than planting on flat land. This is especially true of the women farmers. Some male farmers cultivate cassava, rice, and yam solely. In all four communities surveyed, farming was shown to be the primary source of income, although only a small number of farmers are also engaged in non-farm pursuits like trading, fishing, and livestock raising.
Key words: *Gender, Farming system, livelihood activities, cassava farmers*

INTRODUCTION
In Nigeria, cassava is one of the principal crops grown for food staples. Due to Nigeria's strategic position as the world's greatest producer, it is well acknowledged to have significant potential to improve the nation's economy (FAO, 2016). According to FAOSTAT (2019), Nigeria produced 59.4 million metric tons alone (20.4% of the global production). According to Ewubare and Ologhadien (2019) evaluation of the cassava sector's potential in Nigeria's national economy, the industry has the ability to provide 1.8 million employment, guarantee food security, raise farmers' incomes, and generate foreign exchange gains, among other things. Nigeria is in a prime position to gain from the global cassava value chain due to her position in the world's cassava output.
Additionally, the demand for alternative energy sources, fuel, animal feed, and beverages, as well as the Nigerian government's drive to replace imported wheat and food (especially for gluten-free diets), are driving up other economic opportunities in the cassava sector globally. Cassava is presently the most widely grown crop in Nigeria after changing over time from a low yield famine reserve crop to a high yielding cash crop (Apata, 2019). Smallholder farmers in Nigeria account for 95% of all cassava production, and they are the main producers and growers of the crop (Otekunrin and Sawicka, 2019).
Cassava is grown in Nigeria either as a single crop or in combination with other crops as part of intercropping farming techniques. Because cassava is a year-round crop that provides household food security, reduces poverty, and provides a stable source of income, it integrates well into the farming systems of the smallholder farmers in Imo State, South-East Nigeria. Cassava is more tolerant of low soil fertility and more resilient to drought, pests, and diseases than cereals are. The predominant use of this system is due to Nigeria's primarily tropical environment, which is excellent for the cultivation of cassava. In addition to providing the farmer with a secure and consistent income, intercropping cassava with other arable crops protects against crop failure that could result from pest and disease infestation or natural disasters. Additionally, it offers rural households a balanced diet. In many agricultural farming systems in the southeast of Nigeria, maize, yam, melon, okro, and vegetable are interplanted with cassava, which is typically the base crop. One of the two popular crop combination systems used in Imo State, Nigeria, is the cassava-based crop system (CBCM) (Osuji & Onubuogu, 2018).
It is obvious that farm-based businesses and non-farm activities provide a living for rural households. According to Mgbada (2010) and Olawuyi and Rahji (2012), farming of crops like cassava, maize, yam, and vegetables,

raising livestock like chickens, sheep and goats, and raising pigs, and fishing are the main sources of income for rural households. Petty trade, teaching, basket making, palm wine tapping, masonry, food vending, tree felling, food processing, farm labor, carpentry, and tailoring are some further professions. According to the International Centre for Development Oriented Research in Agriculture (ICRA, 2015), livelihood is best understood in this context as primarily including earning money, which serves as a way of achieving other goals. It encompasses aspects of ensuring access to food, housing, healthcare, security (reduced vulnerability to climatic, economic, or political shocks, etc.), sustainability (the capacity to continue to earn a living that is satisfying), and other factors power (the capacity to shape one's own future), as well as others. Gender issues are heavily impacted by Nigeria's ability to boost food production. According to FAO (2006), the reason food security policies and programs fail is because it is assumed that vast populations of people are homogeneous rather than made up of diverse socioeconomic groups with varied demands and interests.

In Nigeria, women perform the lion's share of the labor involved in growing and processing cassava. Cassava is therefore perceived as a "women's crop" in some ways (Otunba-Payne, 2020). Cassava is crucial to ensuring food security in the home, which is frequently the responsibility of women. Additionally, cassava is a low-risk and low-input crop, which is crucial for women who face more severe barriers to accessing agricultural inputs than men (Osuji, & Onubuogu). Men control more productive resources and make more decisions about farming than women do. Women's ability or inclination to adopt innovations is impacted by the disparity in decision-making power and one-sided access to agricultural inputs and technologies, which reduces yield potential (Olaosebikan et al., 2019).

The study of gender focuses on how men and women interact in terms of their roles, needs, and access to and control over scarce resources. Therefore, one of the main causes of gender disparity is thought to be the limited access that women have to some productive agriculture inputs. Differences in home welfare, functions, enterprise, farm sizes cultivated, and profit-maximizing conduct are taken into account in this case (Amah et al. 2020). In order to produce agricultural products, women must plant, cultivate, harvest, process, and prepare them (Ajani 2008). In Nigeria, geography, culture, and religion all play a significant part in determining how women are represented in agriculture. Among other communities, like the Igbo and Yoruba, gender-differentiated cropping patterns frequently endure. For instance, transitory crops like cassavas, melons, beans, maize, and cocoyams are regarded as feminine crops while yams, the prestige crop, is viewed by agriculturalists as a masculine crop. In the state of Imo, both men and women work as farmers, raising crops like cassava and others for a living. They engage in additional activities to earn money. Gender inequalities in farming systems, labor tasks, access to and control over resources utilized in the production of cassava and other livelihood activities must be included in agricultural research and extension. This study is undertaken to examine gender differences in farming system of cassava as well as other livelihood activities performed by farmers in Imo state to ensure food security and poverty alleviation in their rural communities.

METHODOLOGY

The survey was conducted in Imo state with all the three agro-ecological zones that made up the state inclusive. The communities studied were Uzoagba, Ikeduru, selected from Owerri zone, Akwakuma, Owerri North from Owerri zone, Amandugba Isu from Orlu zone, Isinweke, Ihitte Uboma, from Okigwe zone. All these areas were well known for production of cassava in large quantity. Purposive sampling technique was used to select key informants who are knowledgeable about cassava production and farming system in their various communities. Some of the key informants are traditional rulers, councilors and primary and secondary school teachers. From each community, one male and one female key informants were selected to represent the community making a total of (8) key informant interviews for the four (4) communities selected for the study. In-depth interview with eight (8) Key informants from the four selected communities was carried out. Ten individual interviews were also conducted for each community making a total of fourty (40) individual interviews, market interview was also conducted for each community studied. Two (2) focus group discussions were carried out in each community studied, one male group and one female group making a total of eight (8) Focus group interview. Each group was comprised of Ten (10) discussants /respondents making a total of eighty (80) respondents that participated in Focus group discussion. Thus, a sample size of one hundred and thirty two respondents (132) was used for the study. Separating the male group from the female group enable the researcher in eliciting quality response from the farmers because every respondent will be free and willing to give correct information without the fear of being confronted by her husband at home after the meeting. The collected data were analysed by transcribing the responses of the discussants.

RESULTS AND DISCUSSION

It was discovered from table 1 that both gender groups (men and women) farmers in various community mainly plant their crops on mounds and ridges because it yields more crops and ease weeding unlike planting on flat land, some still plant on flatland because they do not have enough money to hire labourers to make mounds or ridges for them but it was reported in women FGD Umundugba that why some people plant on flat land is because some areas are very soft that cannot permit any form of land preparation, also, most communities practice intercropping mainly peasant farmers because they do not have enough land, rotational cropping is practiced by female farmers in Ihitte Uboma that have enough land. It was also discovered that some crops like cassava, rice and yam are planted sole in Men FGD in Ihitte Uboma. Even though that men and women perform most activities in the farm together, Men are mostly involved in land preparation activities like bush clearing, ploughing, harrowing and ridging / mound making while women are mostly involved in planting, maintenance of the farm like fertilizer application and harvesting.

Table 1: Farming practices

Male/female FGD + Community name	Farming practice	People who practice
Women's FGD, Uzoagba (Umuloboagwu)	In this community, mounds are preferred due to their higher yields, less weeds, and ease of weeding, while flat ones are preferred due to their lower cost.	Women, Men, Men do the cleaning of bushes
Men's FGD, Uzoagba,Ikeduru	Cultivation methods include ridges, mounds, flat soils, and single or multiple cassava stems, with flat ones being preferred due to cost-effectiveness.	Women, Men, Youth and Migrant farmers. But women does the farming more than the men..
Women's FGD, Akwakuma, owerri	Farming practices vary based on social segmentation, with peasant farmers using intercropping for land conservation and commercial farmers using mono-cropping and tractor cultivation for large land expanses.	Men plant yam, they cut the wood, make the mounds and stake them. Men do the strenuous work and slash the farm land. The women weed the farm, plant the cassava and also uproot the cassava mainly
Men's FGD, Akwakuma, owerri	Making of ridges, mounds, we also have the cassava planted on flats and covered with soil. To ease work and conserve land.	Both the men women perform the task.
Women's FGD, Umundugba Isu	Farmers use ridges, heaps, or flat ground for planting due to soil fertility in soft areas, allowing stems to grow without creating ridges or heaps.	In a community, men and women work on farms, with women mainly involved in slashing and removing bamboo trees. Age doesn't stop them, and some even sit on chairs.
Men's FGD, Umundugba Isu	We plant on ridges, heaps, small mounds and on flats, but majorly on ridges and heaps.	Men plant on ridges, while women plant in mounds. Men plant on ridges, while women plant short, 2m-long ridges due to stumps.
Women's FGD Isinweke ihitte uboma	We use mounds to plant. We do crop rotation here, but some who have no land do not practice it. Generally we lack land.	Men traditionally clear bushes and plant, but women now do these tasks. Most men are lazy, except for those in agriculture, who don't like to help. Only 5 men assist their wives.
Men's FGD Isinweke Ihitte Uboma	Family members farm together, planting crops like cassava, yam, and rice on ridges mounds, depending on soil type and topography.	Men prepare land, plant yams, and perform weeding, clearing, and harvesting, with women mainly handling weeding and fertilizer application.

Field Survey, 2018

Table 2 revealed that farming was the major livelihood activities for all the communities in the sample. They specialized in the production of mainly food crops like cassava, plantain, maize, yam, vegetables and oil palm that provides them with food for the family and serves as source of income for their livelihood. However, men in Umundugba and Ihitte Uboma reported fishery and other livestock like poultry, sheep and goat production as an additional means of livelihood activities. Women group in Umundugba reported that cassava and other food crops are majorly produced by women while men specialises in yam production. The four communities studied also process their cassava into gari and sell to meet up with other household needs of the family. Very few people in Uzoagba are involved in trading.

Table 1: Livelihood activities

Male/female FGD + Community name	Livelihood activities and people they are involved
Women's FGD, Uzoagba (Umuloboagwu	Majority are farmers few people are tailors and hair dressers. They produce palm oil, trade, they also sell plantain and bananas, they grow mainly food crops. Only few people trade.
Men's FGD, Uzoagba,Ikeduru	The main livelihood activities is all about farming in which they produce palm fruit, cassava, poultry, vegetables and some others engage in labouring work as a means of livelihood.

Women's FGD, Akwakuma, owerri	They plant food crops like maize, cassava, yam, cucumber, plantain, pumpkins, pineapple etc. They also process cassava into garri, they make it for them to have food in their homes. They also plant to help their family members that do not have enough and also for exercise. when we farm in large quantity, we get money to pay school fees of our children. Farming also keeps our youth busy and not wait until government give them white collar jobs.
Men's FGD, Akwakuma, owerri	They plant lots of crops, like cassava, yam, plantain, vegetables, maize, okro, melon
Women's FGD, Umundugba Isu	Production of cassava, yam, plantain, banana, cocoyam (we used to plant this, but now we don't because it always dies off), akidi, cucumber, water melon, garden egg. Men specialises more in yam, while women focus more in cassava and the rest.
Men's FGD, Umundugba Isu	Livelihood activities include farming-cassava, cocoyam, yam, plantain, palm, livestock etc. we also engage in fishery production
Women's FGD Isinweke ihitte uboma	They plant many crops and we also engage in the production of food crops. we also process them and sell in the market to make money which we will use to buy other things we need.
Men's FGD Isinweke Amakohia Nkwumeato ihitte uboma	They produce Cassava, plantain, Oil palm, plantation, yam, maize, rice, they also process palm fruit into red oil, They rear livestock such as: poultry production sheep and goats,

Field Survey, 2018

CONCLUSION

Though it was also discovered that some who have very soft land also plant on flat land and few who cannot afford to hire labor for cultivation, they also practice intercropping particularly women and those who do not have enough land. It is clear from the study that male and female farmers in Imo state almost have the same farming practice where they plant their crops on mounds and ridges because it yields more crops and eases weeding unlike planting on flat land. Cassava, rice, and yam are reportedly solely planted, according to some men. Some communities that have land also practice rotating crops. Most of the land preparation activities like bush clearing, ploughing, harrowing, ridge and mound making are done by men while planting and maintenance operation like wedding, fertilizer application are done by women. Farming was also found to be the major livelihood activities for all the communities studied but few farmers are involved in non-farm activities like trading, fishery and livestock production like poultry, sheep and goat rearing as additional means of livelihood.

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PROCEEDINGS OF THE

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Federal University of Lafia Nasarawa State

"LAFIA"

SUB-THEME 4:

Youth Involvement in Smart Agriculture and Value Addition

CONSTRAINTS MILITATING YOUTH'S ENGAGEMENT IN AGRI-BUSINESS ACTIVITIES IN ZAMFARA STATE, NIGERIA.

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ABSTRACT
A research was conducted to identify the constraints militating youth's engagement in agribusiness activities. Three hundred and sixty respondents were randomly selected from three agricultural zones in Zamfara State. Majority (43.1%) of the respondents agree that the problem militating against youths' engagement in Agri–business activities is lack of interest. The "poor or wrong counseling towards Agribusiness" activities is another constraint where majority of the respondents (40.6%) in the study area agreed with the statement to be one of the constraint militating youth engagement in agribusiness activities. Recommendation made is that all stake holders especially policy makers, religious leaders as well as the community leaders should developed training and retraining of youth with the aim of sensitization and awareness of the important of their engagement in any legitimate agribusiness activity
Keywords: *Youth, Agribusiness, Engagement Activities*

INTRODUCTION
One of the pitfalls of the global economic crisis is the rising of unemployment, particularly among the youth. Despite the percentage of youth and their contribution to national development, there are challenges facing youth in the society. Today, millions of youths including young university and polytechnic graduates are roaming the streets without any hope of getting white collar jobs or business to do. In fact, there has been a growing commitment across Nigeria and Africa in engaging youth in agribusiness as cited by Mastewal *et al*. (2019) which include several initiatives such as N- power (i.e. N-agro) in (2016 to date), Fadama guys program in (2016), the adoption of the African Youth Charter (AYC) by the African Union in 2006, the declaration of the Youth Decade Plan of Action (2009 to 2018), the establishment of the Youth Desk in the New Partnership for Africa's Development (NEPAD, 2017) and the Comprehensive African Agriculture Development Program (CAADP) (AGRA, 2016). Despite all the efforts made by several governments, in engaging the youth to participate in agribusiness, the outcome of their efforts is less satisfactory. This research is trying to find out factors or constraints militating youths' engagement in agribusiness.

METHODOLOGY
Study Area
Zamfara state is one of the thirty-six states of Nigeria. It is located in the north-western zone of Nigeria between latitude 12.1844^0 N and longitudes 6.2376^0 E with and altitude (feet), 1049 (FRN, 2006). The state has a total land area of 384.18 square kilometers and with a population of 3,602,356 according to the 2006 census. The arable land includes a large expanse of Fadama area (FRN, 2006).
Multistage sampling technique was used in selecting the respondents for the study. . The first stage is the purposive selection of the agricultural zones (zone A, Zone B and Zone C) in the state. The second stage involve random selection of the respondents living in those selected locations. Initially, a respondent will be ask about his age before proceeding to the actual interview. Any respondent whose age is above 30 years will not be allowed to participate in the interview. One hundred and twenty respondents were randomly selected in each of the three agricultural zones making the total of three hundred and sixty respondents used for the study in providing the necessary information for the research.

Descriptive statistics such as frequency distributed count, percentages were used in analyzing the data. Likert scale was developed for measuring the constraints militating youth engagement in agribusiness related activities by asking people to respond to a series of statements about a topic, in terms of the extent to which they agree with them. Likert-type or frequency scales use fixed choice response formats and are designed to measure attitudes or opinions (McLeod, 2008). These ordinal scales measure levels of agreement/disagreement. A Likert-type scale assumes that the strength/intensity of experience is linear, i.e. on a continuum from strongly agree to strongly disagree, and makes the assumption that attitudes can be measured.

RESULTS AND DISCUSSIONS

Table 1 shows the constraints that militating against youth's engagement in Agri – business activities in the study area (i.e. Lack of interest, poor or wrong counseling towards Agri – business activities, societal norms/values and Religious purpose).

Table 1. The Constraints Militating Youths Engagement in Agribusiness Activities

Variables	Frequency	Percentage
Lack of Interest:		
SD	67	18.6
DA	33	9.2
UD	26	7.2
A	155	43.1
SA	79	21.9
Total	**360**	**100.0**
Poor counseling toward Agribusiness		
SD	28	7.8
DA	54	15.0
UD	52	14.4
A	146	40.6
SA	80	22.2
Total	**360**	**100.0**
Societal Norms and Value:		
SD	37	10.3
DA	37	10.3
UD	62	17.2
A	154	42.8
SA	70	19.4
Total	**360**	**100.0**
Religious Purpose:		
SD	38	10.6
DA	41	11.4
UD	41	11.4
A	132	36.7
SA	108	30.0
Total	**360**	**100**

Source: Field survey 2020

On "lack of interest" majority 43.1% of the respondents agree that the problem militating against youths engagement in Agri – business activities is lack of interest, 21.9% undecided, 18.6% of the respondents strongly disagree while 9.2% of the respondents disagree and also 7.2% of the respondents undecided with the statement. The finding is in consonance with those of Adekunle *et al,* (2009) identified lack of interest, as the most important factor militating youth in engaging agribusiness activities.

The "poor or wrong counseling towards Agri – business" activities, majority of the respondents (40.6%) in the study area are agreed with the statement, (22.2%) of the respondents strongly agreed, while (15.0%0 of the respondents disagreed second to the least is (14.4%0 of the respondents are undecided and (7.8%) of the respondents are strongly disagreed, that poor counseling toward Agri – business is a constraints that militating youths engagement toward Agri – business activities in the study area.

Majority of the respondents (42.8%) agreed that the "societal norms and value" is a constraints toward Agri – business activities, 19.4% of the respondents strongly agree, 17.2% of the respondents are undecided with the societal norms and values and both disagreed and strongly disagreed having the same percentage of (10.3%) of the respondents. This finding is also in line with the research conducted by Adekunle *et al.* (2009) who classified the constraints hindering, youth's to engage in Agri – business activities into economic factors, social factors and environmental factors.

"Religious purpose" of the respondents indicated the majority of the respondents (36.7%) agreed that religion have influence on what to buy and sale, 30.0% of the respondents in the study area are Strongly agreed while both undecided and disagreed have the same percentage (11.4%) of the respondents and 10.6 of the respondents strongly disagreed that religion is not constraints towards youths engagement in Agri – business activities. This research is also in line with the study conducted by Oneukwusi and Attan (2006) stated that lack of incentives, religious purpose, insufficient land, lack of infrastructure in the rural areas, inadequate training and extension sources and inadequate labour reduces rural youth's participation in agricultural activities.

RECOMMENDATIONS

Based on the findings the study recommend that all stake holders especially policy makers, religious leaders as well as the community leaders should developed training and retraining of youth with the aim of sensitization and awareness of the important of youth engagement in any legitimate agribusiness activity regardless of the position of the business at societal level. This will reduce dependency of youth waiting for lucrative job.

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INVESTMENT CHALLENGES AMONG YOUTH ENTREPRENEURS IN ORANGE-FLESHED SWEETPOTATO VINE PRODUCTION IN NORTH CENTRAL NIGERIA.

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ABSTRACT

The analysis of cost and returns on investment, and investment challenges among youth entrepreneurs involved in Orange-fleshed Sweetpotato (OFSP) vine production enterprise in North Central, Nigeria was carried out. Multistage sampling was used to select 139 youth entrepreneurs in Benue, Kwara and Nasarawa. A structured questionnaire designed for a single visit was used for data collection. Descriptive statistics was used to analyze cost and returns in OFSP vine production and double log regression determine the investment challenges among Youth entrepreneurs involved in OFSP vine production in North Central Nigeria. The result shows that OFSP vine production is a profitable venture with 74%, 76% and 66% return on investment in Benue, Kwara and Nasarawa states respectively. The regression analysis result shows that the amount of savings, access to credit, access to market, access to information, vine output price, access to land and farm experience were very significant in positively influencing investment in OFSP vine production in North Central, Nigeria. The cost of inputs and taxes were significant but negatively influencing investment challenges in OFSP vine production among youth. Policies aimed at enhancing saving habits among young people, access to credit, access to market, access to information and other measures that will enhance and sustain investment in OFSP vine production in Nigeria.

Keywords: *Investment Challenges, Youth Entrepreneurs, Orange-Fleshed, Sweetpotato Vine, Production*

INTRODUCTION

Orange-Fleshed Sweet potato (OFSP) is an improved breed of sweet potato (*Ipomea batatas* [L.] *Lam.*) cultivated in tropical and semi-tropical regions of the world for food and source of income especially among the rural dwellers (Adebisi, *et al.*, 2015; Padmaja, 2009; Mitra, 2012). Sweetpotato is one of the most important and versatile root crop in the world (Udemezue and Eluagu, 2021). Globally, sweetpotato is cultivated in eleven countries producing approximately 88.9 million metric tons (Shahbandeh, 2023). According to the Food and Agriculture Organization statistics (FAOSTAT) in 2022 reported that Nigeria is the third largest producer of sweetpotato in the world after China and Uganda with an annual production estimated at 3,867,871 tons.

In 2021, the annual export value of raw potatoes amounted to about 4.32 billion United State dollar worldwide. The export value of sweetpotato is an indication that there is a huge economic potential that present investment opportunities for young entrepreneurs. Sweetpotato health and nutritional benefits have expanded globally owing to rising popularity and demand. According to Data Bridge Market Research (2022), Sweetpotato market globally is expected to account for 50,534.33 million United States Dollar by year 2029. Some of the factors driving the market growth are awareness of sweetpotatoes' health benefits, increasing applications of sweetpotato in food and beverages, and growing consumers' awareness about the health benefits. Investment in OFSP vine is attractive because of the growing market of functional food dietary supplements, various product launches and development and government home grown school feeding programme. Therefore, promoting increased youth investment in Orange-fleshed Sweetpotato (OFSP) vine production has significant health and nutrition as well as employment generation and poverty reduction implications.

This observation aligned with the finding of Adesina *et al.* (2018) that there is low level of investment in OFSP production in spite of its huge economic potential. However, in spite of the potential benefits of youth entrepreneurship in agribusiness, there are no sufficient empirical studies on investment challenges among sweetpotato vine multipliers. Therefore, it has become imperative to investigate investment challenges affecting youth entrepreneurs in OFSP vine production. This study seeks to analyse investment challenges among young OFSP Vine multipliers in North Central Nigeria. This paper attempts to fill the knowledge gap by specifically: (i) analyse the cost and returns in OFSP vine production, and (ii) determine the investment challenges among Youth entrepreneurs involved in OFSP vine production in North Central Nigeria.

METHODOLOGY

The study was conducted in Benue, Kwara and Nasarawa states in North Central geo-political zone of Nigeria. This geo-political zone was chosen based on the intensity of orange-fleshed sweetpotato production. A multistage sampling procedure was employed in selecting the respondents in this study. The first stage involved the purposive selection of three states out of six states in the North central based on their distinct OFSP production (NRCRI, 2012). The three states were Benue, Kwara and Nasarawa. The second stage involved the purposive selection of Local Government Areas (LGAs) from the three selected states based on the intensity of OFSP production namely: Gboko, Konshisha, Kwande, Makurdi and Vandeikya in Benue while; Edu, Ifelodun, Illorin East, Irepodun and Patigi in Kwara state; and Karu, Lafia, Keffi, Nasarawa Egon and Obi in Nasarawa State. In the third stage 139 OFSP vine multipliers who were not older than 35 years were selected from the sampled local government areas based on sampling frame from the respective ADPs for the analysis of investment challenges in OFSP vine production. Data were collected with the aid of structured questionnaire. Descriptive statistics was used to achieve objective one and regression models were used to achieve objective two. Following Odoemenem *et al*. (2013) who investigated the saving and investment pattern of small-scale farmers in Benue state Nigeria, regression model was adopted for the analysis and specified as follows:

$$\ln Yi = b_0 + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + b_7 \ln X_7 + b_8 \ln X_8 + b_9 \ln X_9 + b_{10} \ln X_{10} + b_{11} \ln X_{11} + + e_i \quad (1)$$

Where:Yi = investment challenges proxies by OFSP vine share of farm investment (₦), X_1 = amount of savings (₦), X_2 = access to credit (1 = yes, 0 = otherwise), X_3 = access to market(1 = yes, 0 = otherwise), X_4 = inputs cost (₦),X_5 = access to market(1 = yes, 0 = otherwise), X_6 = Vine output price (₦), X_7 = access to market(1 = yes, 0 = otherwise), X_8 = farm experience (years), X_9 = risk management (high = 1, low = 0), X_{10} = taxes (high = 1, low = 0), X_{11} = Security (existence of security = 1, otherwise = 0), ln = natural logarithm, b_0 = intercept on dependent variable, $b_1 – b_{11}$ = parameters to be estimated, and e_i = error terms.

Equation (1) predicted that investment challenges will be positively affected by all the independent variables. The model linearized so as to standardize the variables

RESULTS AND DISCUSSION

The result in Table 1 shows the mean of total revenue (TR), total variable cost (TVC), gross margin (GM) and return on investment (RoI) in orange-fleshed sweetpotato vine production of the sample households. The result indicates that an average OFSP vine entrepreneur in Benue state spent an average of ₦95,116.15 on OFSP vine production. The result also reveals that the average variable cost in OFSP vine production in Nassarawa and Kwara States are ₦195,300.00 and ₦80,700.00 respectively. An average OFSP vine entrepreneur in Benue, Nassarawa and Kwara States obtained ₦166,172.31, ₦323,600.00 and ₦142,250.00 revenue respectively from OFSP vine production.

Table 1: Summary of total revenue, total cost, gross margin analysis and returns on investment in orange-fleshed Sweetpotato vine enterprise of the sample Households (n=139)

		Total Revenue (₦)		Total Variable Cost (₦)		Gross Margin ₦/ ha		Return on Investment (%)
State	N	Mean	±SD	Mean	±SD	Mean	±SD	
Benue	13	166172.31	80774.67	95116.15	43502.63	71056.15	48272.78	74
Kwara	4	142250.00	58823.89	80700.00	34996.57	61550.00	25989.93	76
Nassarawa	5	323600.00	98431.70	195300.00	82379.91	128300.00	38742.10	66

Source: Computed from updated field Survey data (2022)

The gross margin for orange-fleshed sweetpotato vine enterprise in Benue state is ₦71,056.15 per hectare. This shows that OFSP vine enterprise is a profitable venture in Benue state. The result of return on investment shows 74 percent return on investment from OFSP vine production in Benue state. This implies that one naira invested in OFSP vine production in Benue state will yield a return of seventy four (74) kobo. In Kwara state, the gross margin is ₦ 61,550.00 per hectare and return on investment is 76 percent from OFSP vine production. This implies that one naira invested in OFSP vine production in Kwara state will yield a return of seventy six (76) kobo. In Nassarawa state, the gross margins for OFSP vine enterprise is ₦128,300.00 per hectare and return on investment is 64 percent from OFSP vine production. The implication is that any one naira invested in OFSP vine production in Nassarawa state will yield a return of sixty four (64) kobo. The result of the ordinary least squares (OLS) estimates of the investment challenges among OFSP vine entrepreneurs is presented in Table 2. The double log regression model was accepted as lead equation based on its high value of R^2 adjusted and minimum standard error.

Table 2: Ordinary least square estimates of investment challenges among orange-fleshed sweetpotato vine entrepreneurs (n=139)

	Linear		Semi log		Double Log	
Variable	Coefficient	P. Value	Coefficient	P. Value	Coefficient	P. Value
Constant	-98183.311(-2.474)	0.015**	3.063(12.361)	0.000***	-0.762(-0.591)	0.555
X_1 Amount Of Savings	0.448(8.409)	0.000***	$1.560x10^6$ (4.695)	0.000***	0.078(3.542)	0.001***
X_2 Access to credit	13592.733(1.390)	0.167	0.175(2.869)	0.005***	0.075(1.133)	0.002***
X_3 Access to market	2886.107(1.300)	0.196	0.020(1.421)	0.158	0.056(1.302)	0.000***
X_4 Inputs cost	-0.869(-0.746)	0.457	$3.815x10^6$ (0.525)	0.601	-0.013(-0.693)	0.000***
X_5 Access to information	484.567(0.167)	0.867	0.015(0.853)	0.395	0.011(0.277)	0.020***
X_6 Vine Output price	81.403(1.259)	0.211	0.001(3.071)	0.003***	1.592(4.817)	0.000***
X_7Access to farm land	174.122(2.127)	0.035**	0.002(4.198)	0.000**	2.006(4.466)	0.000***
X_8Farm experience	-1.221(-0.130)	0.897	$5.727x10^6$(0.098)	0.922	-0.034(-1.238)	0.000***
X_9 risk management	-7.480(-1.192)	0.236	$-4.190x10^5$(-1.069)	0.287	-0.016(-0.624)	0.533
X_{10} Taxes	-0.020(-0.112)	0.911	-7.962x10(-0.699)	0.486	-0.027(-1.611)	0.000***
X_{11} Security	3395.931(0.268)	0.789	-0.001(-0.010)	0.992	0.017(0.351)	0.726
Model Fitness Parameters						
R^2	0.579		0.396		0.591	
Adjusted R^2	0.524		0.315		0.552	
Std Error	57495.176		69039.137		0.3566	
F-Stat	10.410		4.907		9.572	
Prob.	0.000***		0.000***		0.000***	

Source: Computed from updated field survey data (2022)
***Sig. At P≤0.01; **Sig. at P≤0.05; *Sig. at P≤0.10. Figures in parenthesis are t-test statistics. Accepted Model is double log regression.

Majority of the variables have positive elasticities which implies that most of the variables have positive influence on investment challenges among OFSP sweetpotato vine entrepreneurs. The coefficients of amount of savings, access credit, access market, access to information, vine output price and access to farm land are positive and statistically significant at 1 % level of probability indicating that 1 % increase in amount of savings, vine output and vine price will increase OFSP vine farm investment by 0.078 %, 0.075 %, 0.056 %, 0.011 %, 1.592 % and 2.006 % respectively. The coefficients for input prices and taxes are negative and statistically significant at 1 % level of probability. This implies that a 1 % increase inputs cost would lead to 0.013 % decrease in OFSP vine farm investment when other variables are constant. The inverse relationship between OFSP vine farm investment and variable inputs cost goes to explain the impact of escalating cost of inputs on agricultural productivity and investment. The implication is that any policy decision geared towards encouraging investment in OFSP vine production must enhance OFSP vine entrepreneurs' access to low cost inputs market.

CONCLUSION

The study analysed the profitability of OFSP vine production enterprise and investment challenges proxies as OFSP vine share of farm investment among youth entrepreneurs involved in orange-fleshed sweetpotato vine multiplication enterprise in North Central, Nigeria. It is concluded that OFSP vine production is a profitable venture with high return on investment in the study area. It is also concluded that amount of savings, access to credit, access to market, access to information, vine output price, access to land and farm experience are major challenges affecting youth entrepreneurs in investment in OFSP vine production in North Central, Nigeria. The cost of inputs and insecurity variables were significant but negative suggesting that an increase in cost of inputs and taxes will reduce amount of farm investment in OFSP vine production among youth. The policy implication is that efforts aimed at enhancing saving habits among young people, access to credit, access to market, and access to information should be encouraged. Therefore, in order to achieve sustainable youth participation in strengthening agriculture for food and nutrition security, the escalating cost of inputs and worrisome taxes should addressed to increase investment in OFSP vine production among youth in Nigeria.

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ANALYSIS OF YOUTH PARTICIPATION IN CASSAVA VALUE CHAIN ACTIVITIES IN KOGI STATE

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ABSTRACT
The study was carried out to assess youth's participation in cassava value chain activities in Kogi State, Nigeria. A multi-stage sampling technique was used to select 172 young cassava farmers and data collected were analyzed using simple descriptive statistics and probit regression analysis. The level of value addition was measured using Net Income analysis. The result showed that Cassava value chain activities were highly participated by youth with garri (31%) and cassava flour processing (21 %) were the most involved by the youths. the Net Income analyses showed a Benefit cost ratio of garri (1.54), cassava flour (1.89) and akpu/fufu (1.34) with cassava flour being the most profitable among the value chain. The probit analysis showed that age, household size, ownership of processing equipment, amount of value added to cassava, credit access and availability of public infrastructure were the factors that influenced youth participation in cassava value chain activities. Constraints to youth participation were; Lack of technical-know-how to adopt cassava technologies and poor access to credit facilities. It was recommended that government should increase access of farmers and agricultural processor to credit facility with low interest rate and that the capacity of the youth should be developed in cassava value activities in the study area.
Keywords: *Participation, Value Chain, Activities, Youth*

INTRODUCTION
The bedrock of Nigeria economy is the Agricultural sector. It makes up about 30 percent of total GDP (NBS, 2023), in addition to the extensive employment opportunities it offers to the majority of Nigerian citizens (70 percent of the employed population) and it is seen as an activity that cuts transcends every facet of the country (Osinowo, 2012). In spite of all the agricultural interventions and policy in Nigeria, the number of food insecure households was estimated below 20% in 1986 (Babatunde *et al.*, 2015) this figure had increased to 40% in 2005 and much higher in the subsequent years (Edache, 2013; Folorunsho, 2015). This predicament stemmed from events such as deterioration in Agricultural productivity, decline in the use of agricultural technology, limited value addition to farm product and insignificant focus on youth in agriculture. This has accumulated to the incapability of the Agricultural sector in providing adequate food in quantity and quality to feed the teeming population. Value chain includes all the procedure that begins with the production of a raw commodity and ends with the consumption of the final product and this also encompasses all the value addition undertaken between these phases such as: processing, delivery, wholesaling, and retailing (Bellù, 2013)

Recent statistic reveals that Nigeria waste around 9 billion dollars annually due to inadequate post-harvest crop management. A very easy way to alleviate the increasing level of unemployment in Nigeria is to concentrate effort in value addition. International Institute of Tropical Agriculture (IITA) reported by Abubakar, (2013) specified that value addition to cassava is an easy way to change the fortunes of farmers and give them impressive opportunities that would in turn widen the country's economic growth and improve its competitiveness especially in the non-oil sector. Therefore, efforts geared toward adding value to crops, especially cassava require focus now than ever to guarantee the progress of Nigeria's agricultural sector.

Cassava has been depicted as a vital source of energy with very significant food security value similar to most cereal crops (Achinewhu, 2010). It's a special crop that helps farmers to improve their income and possesses unique qualities, which include; ability to produce tubers even at severe weather conditions; tolerance to adverse conditions like barely productive soil, low soil PH and drought; its suitability to food systems in Africa and various farming, little or no external input requirements for its production, ability to produce all year round. These special attributes single cassava out as ideal crop for the tropics (Awah, 2012).

The possibility of converting cassava to various alternative through value addition has resulted in creation of wide food recipes through processing which entails conversion of edible food into another form more receptive or more convenient to the consumer. Examples of value-added products from cassava are starch, flour, chin-chin, bread, chips, flakes, odorless fufu, doughnut, cake, biscuit and salad cream. It is granted that the value addition technology in cassava possesses huge potentiality for rising cassava consumption, varying its uses as well as enhancement of livelihoods of farm families through providing employment opportunities; small agro ventures development income and boosting resources of rural households (Alkali, 2010).

Youth is the state of being young It is a mid-time in personality development that connects the years between childhood and adulthood. The youths are the generation that inherit farming and therefore the future of food security in Nigeria. They may have their farms close to their parents' and supplement their parents' effort by participating in almost all the farm operations. Youths readily adopt technologies and are very innovative but despite their contributions to household agriculture, there exist little empirical data to back it up. Thus, an assessment on the level of youth's participation in cassava value chain activities becomes relevant. This study is significant in order to design appropriate intervention policies and redesign strategies that will involve more youth in agricultural programs. To this end, this study aims at assessing the determinants of youths' participation in cassava value chain activities in Kogi State. Specifically, the objectives of the study are to;

i. profile cassava value chain activities engage by youth in the study area
ii. identify cost and return of cassava value chain activities by youth in the study area
iii. examine level of youth involvement in cassava value chain activities in the study area.
iv. examine the determinant of youth participation in cassava value chain activities in the study area
v. identify constraint faced by youth in cassava value chain activities

MATERIAL AND METHODS

Study Area and Sampling technique

This study was conducted in Kogi State. It consists of 21 Local government Areas with two major season; rainy season and dry season. The sampling technique used for selecting respondents for this study comprised of Multi-stage, purposive and simple random sampling. The state is divided into four Agricultural zone namely; Zone A, B, C, and D respectively. In the first phase,,three (3) Zones was randomly selected (These are zone A, B, and C). In the second stage, two LGA was also randomly selected from each zone giving a total of 6 Local Government Area. Three (3) communities where also randomly selected from each Local Government Area in the third stage giving a total of eighteen (18) communities respectively for the study. Ten (10) youth respondent was randomly selected from each community, these gives a total of 180 respondents in the area.

Method of Data Collection

Primary data and Cross-sectional method was used to collect information from 180 youth's farmers in the study area. Data were sourced directly from the respondents using well-structured questionnaire complemented with interview sessions. These activities were conducted with the assistance of different professional in the survey teams which consist of well-trained enumerators and supervisors who were graduates of agriculture and other related discipline. Local language was mainly used for this interview and occasionally using English language for some respondents who seems educated which help to facilitate their understanding of the survey questions, which allows more accurate responses.

Note: 180 questionnaires was administered to the youth, however, 172 was returned and well filled.

Data analysis

The Data for this study was estimated using descriptive and inferential statistics. The specific objectives of the study were achieved with the following methods: - Objective (i), (ii), and (v) was achieved by using descriptive statistical tools such as frequency distribution, means, percentage and Likert Rating Scale Technique. Objective (iv) was estimated using Probit regression analysis and finally objective (iii) was achieved using Net Income Analysis respectively.

Probit Regression:

The use of Probit model was determined since the response dependent variable is a binary one. Dependent variable of the model comprised of a dummy variable that represents participation of youth in cassava value chain activities (y=1) which signifies that they are participating in cassava value chain activities and the alternative (y=0) when the youth are not participating in cassava value chain respectively. Identified Independent variables included for this model include; age, gender, household size, educational attainment, cassava processing experience, amount of value added, ownership of processing equipment, access to water, access to credit, access to public infrastructure respectively. The model is appropriate since it can resolve the problem of heteroscedasticity and satisfies the assumption of cumulative normal probability distribution (Gujarati, 2004).

The probit model can be specified as shown below:

$$Yi = F(Xi\beta) + \varepsilon i \qquad (1)$$

Y i = (1, if participated 0, otherwise)
where,
ε~N(0,1); β = maximum likelihood; ε = error term; X = set of independent variables included in the model.
Since estimates of the probit model provide only direction of effects, the marginal effects are usually calculated to interpret the actual change in probability of independent variables. Marginal effects = $\beta i\phi(z)$ (2)
where, βi = coefficients of the variables; ϕ(z) = cumulative normal distribution value associated with the mean dependent variable from the probit estimation.
The explanatory variable includes;
X_1 = Age (years)
X_2 = Gender (dummy; female = 1, and otherwise =0)
X_3 = Household size (number of persons)
X_4 = processing experience (years)
X_5 = Educational levels (number of years acquiring formal education)
X_6 = Ownership of processing equipment (dummy; ownership = 1, otherwise = 0)
X_7 = Amount of value added (naira)
X_8 = Credit access (naira)
X_9 = Access to water; (dummy; yes = 1; 0 otherwise)
X_{10} = Members of cooperative (dummy; members = 1; 0 otherwise)
X_{11} = availability of public infrastructure such as good road network, health facility, electricity (dummy; yes = 1 ;0 otherwise)

Net Farm Income

A budgetary technique such as Net Farm Income (NFI) was used to estimate the cost and return of youth in cassava value chain activities. It can be denoted by; -
NFI = TR – TVC – TFC
Where;
NFI = Net Farm Income (₦)
TR = total revenue (₦)
TVC = total variable cost (₦) and
TFC = total fixed cost (₦)
Note: Total revenue was realized from sales of processed cassava tuber and cassava peels which was valued at current market price. Variable cost includes for cassava value chain activities include; cost of grating cassava tubers, cost of cassava tubers, cost of firewood, cost of labour etc., while the fixed cost includes cost of depreciation of assets which include; measuring bowl, frying pan, grating machine screw Jack, knife etc

Likert Rating Scale Technique

In order to determine the level of contribution by youths in cassava value chain activities, four point likert rating scale was adopted. The 4-point scale was graded as High Contribution = 4, Moderate Contribution = 3, Low Contribution = 2 and No Contribution = 1. The level of contribution was ranked using weighted mean (X).
The mean score is 4+3+2+1 = 10/4 = 2.5 (cut-off point). Therefore, using the cutoff point value of 2.50, any item with mean value of 2.50 and above was regarded as" youth participation in cassava value chain activities" while items with mean value of less than 2.50 was regarded as no participation.
The same technique was used to identify constraint militating the youth in cassava value chain activities in the area.

RESULTS AND DISCUSSION

Forms of Cassava value addition participated by Youth

Results from Table 1 shows that majority 31 % of the youth were involved in Garri processing only, 21 % were involved in cassava flour only, 9 % Akpu/Fufu only, 10 % Garri + Flour only, 5 % Garri + Akpu/Fufu only, 11 % involved in Flour + Akpu/Fufu, 7 % in Garri + Flour + Akpu/Fufu, 6 % for Others while none of the youth was not involved in any of the cassava value chain respectively. This shows that processing of Garri and Cassava flour are the most prevalent value chain activities engaged by youths and that cassava value chain activities cut across the length and breadth of the study area.

Table 1: Forms of Cassava Value Addition

S/N	Value addition	Frequency	Percentage (%)
a	Garri Only	53	31
b	Cassava Flour Only	37	21
C	Akpu/Fufu Only	15	9
C	Garri + Flour	17	10
D	Garri + Akpu/Fufu	9	5
E	Flour + Akpu/Fufu	19	11
F	Garri + Flour + Akpu/Fufu	12	7

g	Others	10	6
h	None	0	0
	Total	**172**	**100**

Source: field survey, 2023

Cost and Return in cassava value chain

(A) Garri: The results in Table 2 show the Net Income (NI) analysis of garri processing activities engaged by the youth in the study area. In the result, the total cost (TC) of garri processing is ₦67,150 per ton with Total variable cost (TVC) of ₦65,000 per ton (96.7% of the TC) and Total Fixed Cost (TFC) of ₦2,150 per ton (3.2%) respectively. The sum of ₦100,000 was generated from the sale of garri per ton (this constituted 96.6% of the total revenue) while revenue derived from cassava peel for animal feed is ₦3,500 per ton (3.4%). Total revenue (TR) of ₦103,500 was generated per ton with a total cost (TC) of ₦67,150 respectively. This gives a Net income (NI) of ₦36,350 per ton. Benefit Cost Ratio (B/C) of garri processing is 1.54 with Return on Investment (ROI) of 54k respectively. This shows that garri processing by youth is profitable in the study area.

(B) Cassava Flour: Results from Table 2 on cassava flour processing showed that the total cost (TC) of cassava flour production is ₦63,320 per ton. Breakdown of the cost include total variable cost of ₦61,620 per ton (97.3% of the total cost of production) and total fixed (TFC) of ₦1,700 per ton (2.7%) respectively. Revenue generated from cassava flour is ₦116,300 per ton (96.9% of the total revenue) while ₦3,700 revenue was derived from cassava peel for animal feed per ton (3.1%). Total revenue (TR) generated from cassava flour is ₦120,000 per ton with a total cost of ₦63,320 per ton respectively. This give a resultant Net income of ₦56,680 per ton. The financial analysis further gives the Benefit Cost Ratio (B/C) for cassava flour processing of 1.89 and Return on Investment (ROI) of 89k respectively. This shows that cassava flour processing by youth is profitable in the study area.

(C) Akpu/Fufu: The result in Table 2 showed the Net Income analysis of Akpu/Fufu processing in the study area. Total cost of Production of Akpu/Fufu per ton is ₦68,900. The Total variable cost is ₦67,250 per ton (97.6% of the total cost of production) with total fixed cost of ₦1,650 per ton (2.4%) respectively. Revenue generated from Akpu/Fufu is ₦89,000 per ton (96.2% of the total revenue) while revenue derived from cassava peel for animal feed is ₦3,400 per ton (3.8%). Total revenue generated from Akpu/Fufu is ₦92,480 per ton with a total cost of ₦92,480 per ton respectively. This gives a profit level of ₦23,580 per ton in Akpu/Fufu. Benefit Cost Ratio (B/C) of Akpu/Fufu is 1.34 and Return on Investment (ROI) of 34k respectively. This shows that Akpu/Fufu processing by youth is profitable in the area.

Table 2: **Cost and return in Garri processing/Ton**

Item	**Garri**	**percent %**	**Cassava Flour**	**percent %**	**Akpu/ Fufu**	**Percent %**
(A)Variable cost						
Amount of cassava purchased (₦)	43,750	65	43,750	69.1	43,750	63.5
Cost of grating (₦)	5,250	7.8	-	-	-	-
Cost of labour (₦)	9,000	13.4	15,870	25	12,000	17.4
Firewood ((₦)	3,000	4.5	-	-	10,000	14.5
Cost of Palm oil (₦)	3,000	4.5	-	-	-	-
Bags (₦)	1,000	1.5	2,000	3.1	1,500	2.2
Total variable cost(₦)	65,000	96.7	61,620	97.3	67,250	97.6
(B) Cost of depreciation (₦)	2,150	3.2	1,700	2.7	1,650	2.4
(C) Total cost (₦)	67,150	100	63,320	100	68,900	100
(D) (Revenue)						
Total Output/kg	100 kg	-	400kg	-	200	-
Unit price (₦)	1,000/kg	-	300/kg	-	446	-
Product (₦)	100,000	96.6	116,300	96.9	89,000	96.2
Cassava peels (₦)	3,500	3.4	3,700	3.1	3,480	3.8
Total Revenue (₦)	103,500	100	120,000	100	92,480	100
Net Return	36,350	-	56,680	-	23,580	-
B/C	1.54	-	1.89	-	1.34	-
ROI	0.54	-	0.89	-	0.34	-

Source: field survey 2023

Level of participation by youth in cassava value chain activities

Table 3 described the roles played by youth in cassava value chain activities in the study area.

(A) Level of participation by youth in garri processing activities

The result revealed that the level of participation of youth in garri processing activities were moderately high in 6 out of the 10 identified stages of cassava processing to garri as shown by their respective means which are more than the cut-off point value of 2.50 on 4-point rating scale. The identified stages with their corresponding mean values include: grating (3.4), fermentation (2.7), dewatering (3.2), sieving/sifting (2.9), packaging/bagging (3.3) and storing (3.0) respectively. This indicates that the roles played by youth in garri processing activities are moderately high. However, the involvement of youth was low in pelling (2.2), washing (1.7) frying/roasting (1.4) and drying (2.1) of cassava respectively.

(B) Level of participation by youth in Cassava Flour processing activities

The result showed that 8 out of 10 known stages of cassava flour processing were actively involved by the youth. This is shown by their corresponding means which are more than the cut-off point value of 2.50 on 4-point on the rating scale. This shows that cassava flour processing activities by youth were high in in the study area. The identified stages include; pelling (2.6), chopping (3.2) dewatering (3.6), drying (2.5), pounding (3.0), milling (3.2), sieving/sifting (3.0), packaging (2.9) and storing (3.1) respectively. Only few washing (1.7) and soaking/fermenting (2.3) of the activities were not participated by the youth.

(C) Level of participation by youth in Akpu/Fufu processing activities

The result in Table 3 also showed the level of involvement of youth in Akpu/fufu processing. It showed that 7 out of the 9 identified stages of cassava processing to Akpu/fufu as shown by their means which are more than or equal to the cut-off point value of 2.50 on 4-point rating scale. The identified stages and their mean values are: pelling (2.9), washing (3.1), sieving (2.8), first pounding (3.2), second pounding (2.6) respectively. This shows that the roles played by youth in Akpu/fufu processing activities are moderately high. However, the involvement of youth in soaking and/fermenting (2.1), bagging (2.4), first boiling (2.0), second boiling (1.9) and packaging (1.9) was low respectively.

Table 3: level of participation by youth in cassava value chain activities

S/N	Activities	X	SD	Remarks
(A)	**Garri processing**			
1	Pelling	2.2	0.748	Low
2	Washing	1.7	0.656	Low
3	Grating	3.4	0.980	High
4	Fermentation	2.7	0.611	High
5	Dewatering/pressing	3.2	0.307	High
6	Sieving/sifting	2.9	0.187	High
7	Frying/roasting	1.4	0.454	Low
8	Drying	2.1	0.491	Low
9	Packaging/ bagging	3.3	0.917	High
10	Storing	3.0	0.388	High
(B)	**Cassava Flour processing**			
1	Pelling	2.6	0.440	High
2	Washing	1.7	0.741	Low
3	Chopping/cutting into pieces	3.2	0.728	High
4	Soaking/fermentation	2.3	0.631	Low
5	Dewatering/pressing	3.6	0.317	High
6	Drying	2.5	0.203	High
7	Pounding	3.0	0.454	High
8	Milling	3.2	0.590	High
9	Sieving/sifting	3.0	0.514	High
10	Packaging	2.9	0.361	High
11	Storing	3.1	0.721	High
(C)	**Akpu/Fufu processing**			
1	Pelling	2.9	0.611	High
2	Washing	3.1	0.818	High
3	Soaking/fermentation	2.1	0.661	Low
4	Sieving	2.8	0.377	High
5	Bagging	2.4	0.680	Low
6	First Boiling	2.0	0.544	Low
7	First pounding	3.2	0.695	High
8	Second boiling	1.9	0.440	Low
9	Second pounding	2.9	0.306	High
10	Packaging	1.9	0.711	Low

Source: Field survey, 2023

Determinant of youth participation in cassava value chain activities

Table 4 showed the result of the probit analysis which explained the determinants of youth's participation in cassava value chain activities in Kogi State. The result showed that the Pseudo R2 is 0.4216 which implies that about 42 percent of variations that occurs in youth participation were explained by the independent variables included in the model. However, the remaining 58 percent could be due to other externalities factors that were not included in the model by the researcher. Also, the chi–squared showed gave a statistic of 52.04 which was significant at 1% level of probability indicating the goodness of fit of the overall model over all fitness of good. The t- values shows that six variables; age, household size, ownership of processing equipment, amount of value added, credit access and availability of public infrastructure out of the eleven (11) variables included in the model six (6) were statistically significant at 1%, 5% and 10% level of probability respectively. The coefficient of age was negative and statistically significant at 10 percent level of probability, this signified that age of the respondents had inverse relationship with youths' participation in cassava value chain activities. As the youth's advance in age, the likelihood of their participation in cassava value chain activities decreases in the study area. These can be due to the fact that cassava processing activities is energy snapping enterprise which could be difficult for older people to participate as such should be reserved for young or middle aged farmers. This finding conformed with Nandi et al., (2011) where he observed that farmers within the age of 30-59 are more productive than those farmers above the age of 60 years and above.

In addition, the coefficient of Household size stands positive and statistically significant at 5 percent level of probability. As farmer's household size increases, it increases the affinity with which youth's participate in cassava value chain activities. This could be considered as common norms among rural areas where farmers keep larger household size in other to acquire family labour for farm operation and post-harvest activities.

The results further showed that ownership of processing equipment was positive and statistically significant to youth participation in cassava value chain activities. This suggest that as youth acquire and owned more processing equipment by themselves, it increases their participation in cassava value chain activities. Ownership of processing equipment by farmers increases their chances of making more money when they help in processing cassava for other processor and thus encourage them to participate more in the enterprise.

Amount of value added in cassava value chain activities was also positive and statistically significant to youth participation in cassava value chain activities. This shows that as the youth increases their profits level in cassava value chain activities, it would invariably increase their involvement in cassava value chain activities in the study area. Profits could be considered as the major motivation that enticed an entrepreneur into a business. This results suggest that the more profitable cassava value chain activities, the more time and energy that the youth would be willing to invest in cassava value chain activities in the study area.

The result further revealed that the coefficient of credits access is positive and statistically significant to youth participation in cassava value chain activities. This shows that as youth's have more access to credit facilities in the area, it would increase their participation in cassava chain activities. It was observed that Farmers Productivity, income and welfare can be enhanced when they have access to credit. Quick and timely Access to Short term credit can help farmer to alleviate the problem arising from crop failure, sickness within the family and unexpected social commitment and seasonal needs for working capital. This result is consistence with Philip, Ike, (2012) that reported that when more famers have access to credit supply to farmers, it is widely believed as an effective strategy that increased agricultural productivity. In conclusion, availability of public infrastructure in the study area is positive and statistically significant to youth's participation in cassava value chain activities. This also implied that as level of social infrastructural facilities such as electricity, pipe born water, roads and internet network increases, youth involvement in value chain activities will also increase. This could be premised on the fact that availability of these social infrastructural facilities will encourage youth to stay back in the rural community and participate in agricultural activities instead of running to urban cities in search of collar job that is almost unavailable.

Table 4. Probit regression analysis on determinants of youth participation in cassava value chain activities

Variable	Coefficient	Standard error	Z
Age	-0.052816	0.025638	-2.06*
Gender	-0.96314	0.576730	-1.67
Household size	2.146181	1.007597	2.13**
Processing Experience	0.113142	0.112021	1.01
Educational level	1.043614	1.087098	0.96
Ownership of processing equipment	1.123606	0.513059	2.19***
Amount of value added	2.081383	0.785428	2.65**
Credit access	1.216813	0.533690	2.38**
Access to water	0.141431	0.114057	1.24
Availability of public infrastructure	0.314136	0.157857	1.99**
Members of cooperative	0.193142	0.183945	1.05

LR Chi2(8)	52.04
Prob>Chi2	0.0000***
Pseudo	0.4216

Source: Field survey 2023

Constraints by youth in cassava value chain activities

The result in table 5 shows a four point likert Rating Scale on eleven (11) variables that were used to identify relevant variables that acted as a constraint to youth participation in cassava value chain activities. The result showed that, major problems affecting youths participation in cassava value chain activities include; Lack of technical-know-how to adopt cassava technologies **(3.4),** High cost of processing inputs **(3.3),** Lack of access to credit facilities **(3.2),** Poor road network for transporting fresh and processed Products (3.2), High cost of transportation **(3.1),** Lack of capital for business expansion **(3.1),** Lack of access to market information **(2.9),** Problem of labour shortage in cassava processing activities **(2.7) and** Unstable weather condition **(2.5) respectively.** However, other issues that were not considered as major problem include; poor storage facilities and techniques (2.3) and lack of access to supporting facilities such as extension services (2.1)

Table5: constraints affecting participation of youth in cassava value chain activities

S/N	Constraints	Mean Value (X)	Decision	Ranking
1	High cost of processing inputs	3.3	Accepted	2nd
2	High cost of transportation	3.1	Accepted	5th
3	Poor storage facilities and techniques	2.3	Rejected	10th
4	Lack of access to credit facilities	3.2	Accepted	3rd
5	Poor road network for transporting fresh and processed Products	3.2	Accepted	4th
6	Lack of technical-know-how to adopt cassava technologies	3.4	Accepted	Ist
7	Unstable weather condition	2.5	Accepted	9th
8	Problem of labour shortage in cassava processing	2.7	Accepted	8th
9	Lack of capital for business expansion	3.1	Accepted	6th
10	Lack of access to supporting facilities such as extension services	2.1	Rejected	11th
11	Lack of access to market information by the youth	2.9	Accepted	7th

Source: Field survey, 2023

SUMMARY AND CONCLUSION

Based on the findings of this research work, it can therefore be concluded that major value chain activities engaged by youth in cassava vale chain activities are garri and cassava flour respectively. Similarly, cassava value chain activities participation by youth were found to be profitable and described as a high yielding venture considering the Net Income of garri, cassava flour and akpu/Fufu which was found to be very high. Also, youth participation in cassava value chain activities was moderately high. Therefore, to encourage more youth’s participation in cassava value chain activities, it is recommended that change agent should help to canvass for youth involvement in agricultural activities more especially in cassava value chain activities and also government should increase access of farmers and processor to credit facility with low interest rate (single digit interest rate). It is also suggested that the capacity of the youth should also be developed in the area of cassava value addition, this will help to reduce unemployment and increase food security in the area and Nigeria at large.

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ASSESSMENT OF YOUTH PARTICIPATION IN ACTIVITIES OF AGRICULTURAL ENTREPRENEURIAL DEVELOPMENT CENTRE IN SOUTH EASTERN, NIGERIA

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ABSTRACT
Youth's knowledge and entrepreneurial development through agriculture value chain is increasing gaining prominence as a sustainable livelihood. The study examined youth involvement in the activities of agricultural entrepreneurial development center. Define the socioeconomic characteristics of the respondents, determine the extent of skill acquisition in the chosen EDC'S Programme, and determine the level of participation in agricultural activities. Multi-stage sampling strategy was used in the selection of 240 respondents. Data collection involved using a set of questionnaires. Both descriptive and inferential statistics were applied to the data analysis. The key data showed that 49.2% of the population was between the ages of 31 and 40 with a mean age of 30 years. Over 91% had completed tertiary education, and 33.3% were married. About 33.3% of the population were female, with a male preponderance of 66.7%. Within one to two years, majority of young people (50%) had no job. About 58.3% of the population had entrepreneurial experience between 0 and 5 years; of these, 16.7% were full-time farmers and 50% worked part-time. Youth demonstrated a high level of participation in the areas of livestock production ($x = 2.77$) and crop production ($x = 3.44$) as measured by the overall mean score of 2.61 and the benchmark mean score (decision cut point) of 2.50. Majority of young people (36.7%) were involved in livestock production. Youth should be encouraged by providing various forms of financial support so they can participate in agricultural operations.
Keywords: *Assessment, youth participation, agricultural activities, agricultural entrepreneurship, development centre*

INTRODUCTION
Youth are individuals between the ages of 15 and 24 (UN, 2012). The country definition of youth starts with a lower age from as young as 7 years and some give an upper age limit as high as 39 (Onuekwusi, 2005). This group includes teenagers aged 15 to 19 and young adults aged 20 to 24. The Youth have also been identified as constituting the major Resource base for any country which wants to embark on any meaningful Agricultural and Rural Development Projects (Onuekwusi, 2005). Ugwokwe, *et al.,* (2005) also noted that Youths have been part of the overall agricultural development process in Nigeria because of the immense contribution of Agricultural to the Economy. For enhanced agricultural productivity, youths' strength and energy must be properly channeled and harnessed (Ogunbameru, 2001). For any nation that wants to start any significant agricultural and rural development projects, the youth have also been identified as representing the key resource base (Onuekwusi, 2005).
The National Unemployment Rate in Nigeria in 2016 was 68.1 percent, with youth accounting for more than 40.6 percent of those between the ages of 20 and 34 years (Nigeria Bureau of Statistics - NBS, 2016). Entrepreneurship is the ability and willingness to plan, organize, and run a business enterprise, taking on any risks necessary to do so, with the goal of turning a profit. The creation of new firms is the most obvious illustration of entrepreneurship (Adepeju, 2009). Agriculture-related entrepreneurial endeavors can significantly advance youth development and provide them influence. These initiatives help to reduce youth delinquencies and poverty by giving young people access to employment possibilities. Therefore, it is crucial to promote young people's participation in agricultural entrepreneurial activities (Ogunbameru, 2001).
Youths may find prospects for entrepreneurship in agriculture in the following sectors: crop production (including root and tuber crops), livestock production, agriculture forestry, beverage production, and agro-allied (Glynnis, 2002).

The National Research Council (NRC, 2010) estimates that 2% of the country's population lives in agricultural enterprises, but that percentage is dwindling every year as more farms are becoming urbanized. As a result, many young people have left the agricultural sector. Future leaders and government decision-makers who have an impact on agricultural enterprises are these same kids. The need for rapid development through deliberate policies on agricultural improvement and entrepreneurship skills, developing entrepreneurship spirit among Youth, and providing functional areas of business enterprises including production, marketing, personnel, and finance are just a few of the reasons why this study is thought to be timely.

This study's overarching goal was to evaluate young people's involvement in agricultural entrepreneurial development activities in South East geopolitical Zone.

METHODOLOGY

The South-East Zone of Nigeria, one of Nigeria's six geopolitical zones, is where the study was carried out. The South-Eastern region of Nigeria is made up of the following five (5) states: Abia, Anambra, Ebonyi, Enugu, and Imo. Data for this study were generated from primary sources, and Abia State represents the Centers where the program is carried out. A Proportionate Sampling technique was employed. In the first stage, GEO-EDC were purposively selected because Abia State represents the Centres through which the programme take place. The second stage involved selection of Participants in each Quarters of the programme. South-East Entrepreneurial Development Center (SEEDC), 1st quarter, 2nd quarter, and 3rd quarter. The final stage involved random selection of 20 rural youth's participants in each of the sampled EDC's centres as respondents for the study. The respondents comprises of two hundred and forty (240) end users.

RESULTS AND DISCUSSION

Socioeconomic Characteristics

Age: The South-East Entrepreneurial Development Center's data shows that 49.2% of its participants were between the ages of 31 and 40. The Youths were 30 years old on average. The conclusion is that the majority of responders (49.2%) come within the South-East EDC age group of 26 to 30 years, indicating that they are in their youth and quite productive. In confirmation of Nigeria's National Youth Development policy (2001), the Youth comprises all young persons of age 18-35, who are citizens of the Federal republic of Nigeria. This category represents the most active, the most volatile and yet vulnerable segment of the Nigeria population.

Level of Education: The outcome also reveals that more participants (91.7%) in the South-East zone of EDC had tertiary education attainment. This suggests that implementing modern agricultural technologies and innovations in the training center won't pose too much of a challenge for the trainees (ILO, 2012).

Marital status: The majority of respondents in the South-East zone were married (33.3%), and roughly (40.8) were not married. This tends to agree with the assertion of Odhiambo, (2001), youths are key players in family agricultural and social development activities

Sex: The results also indicated that men made up roughly 66.7% of participants in the South-East EDC Program, while women made up 33.3%. According to the results, more men participate in the EDC Program than women.

Major Occupation: It was also observed that 33.3% engaged in farming and trading, 17.5% took part in farming only while 15.8% hold on to trading, and 15.8% for civil servant respectively in South-east Entrepreneurial activities. This implies that trading is the most prevalent activity in the study area.

Unemployment: The South-East zone had the highest rate of youth unemployment in the study areas, at 50%, within a year to two years. The initiative was created primarily in order to clearly address the issue of rising youth unemployment and its danger to political stability, social cohesion, and the nation's economic growth.

Results indicate that, on average, a youth in the South-East Entrepreneurial Development area of the study had entrepreneurial experience ranging from 0 to 5 years, with 58.3% in that category. The outcome made it abundantly evident that the adolescents are not recent arrivals to the study area's agricultural entrepreneurial activity.

Nature of Participation: In the South-East Entrepreneurial Development Center, half of the young people interviewed (50%) were part-time farmers and (16.7%) were full-time farmers.

The Distribution of Mean Score for the Level of Participation in Agricultural Entrepreneurial Activities of South-East EDC were Presented in Table 2.

Benchmark mean score (decision cut point) was 2.50, while overall mean score was 2.61. According to the aforementioned table, 2 out of the 5 statements on determining the level of participation in agricultural entrepreneurial activities in South-East EDC had a high level of response from youngsters in South-East EDC. Particularly, the youths actively participated when the following assertions were made: Production of livestock ($\bar{x}$ = 2.77); production of crops ($\bar{x}$ = 3.44).

To determine the extent of participation in agricultural entrepreneurial activities in the South-East EDC, the youth disagreed with 3 of the 5 claims. A low degree of participation in agricultural entrepreneurship was specifically evoked for the South-east EDC by the following statements: agriculture forestry ($\bar{x}$ = 2.39); beverage production ($\bar{x}$ = 2.32); and agro allied ($\bar{x}$ = 2.15).

These results demonstrate that the majority of young people have a negative opinion regarding measuring the amount of participation in agricultural entrepreneurial activities in the South-East EDC. These suggest that young people might not comprehend the significance of agricultural entrepreneurial activities in the research area.

Table 3. The Rate of Skills Acquisition in The Selected EDC's Program for South-East.

The majority of young people in the South-East EDC's chosen skills acquisition program (36.7%) are involved in the production of livestock. The conclusion of the study is that the majority of young people in the chosen EDC were engaged in livestock production. This may be due to the lucrative nature of livestock farming, which offers returns on relatively small investments.

Table 4. Socioeconomic characteristic of Youths has no significant influence on Youth Participation in agricultural activities of EDC in the study areas, was tested using regression analysis.

According to the z-test results, youth participation in agricultural operations of EDC in the selected zones had a mean response of 2.61 while youth participation in selected socioeconomic characteristics of youths had a mean response of 2.31. The discrepancy between the mean scores for Selected Socio-Economic Characteristics of Youths and Youth Participation in Agricultural Activities of EDC in the study regions was significant ($\bar{x}$ = -8.41) at P ≤0.05. This suggests that South East EDC'S has made all the numerous activities for youth training in the program as stated mandate available to them. Additionally, it is clear from the program that the trained adolescents in the south-east EDC have not received money to the fullest extent possible, which has had a significant negative impact on their ability to participate effectively in program activities. We reject the null hypothesis that "Selected Socio-economic Characteristic of Youths has No Significant Influence on Youth Participation in Agricultural Activities of EDC in the Study Areas" and accept the alternate hypothesis that "Selected Socio-economic Characteristic of Youths has Significant Influence on Youth Participation in Agricultural Activities of EDC" because the computed z-value of -7.57 was less than the tabulated z-value at (5%) = 3.69 and at (1%) = 11. The investigation came to the conclusion that, despite receiving training, youngsters in the south-east EDC in particular have not received funding to launch any of their numerous agricultural businesses.

Table 1: Socioeconomic characteristics of respondence

Variable	Categories	Frequency (N = 240)	Percentage	Mean
Age (years)				
	16 – 25	10	9.1	
	26 – 30	56	49.2	**30**
	31 – 40	41	34.2	
Education level				
	No schooling	-	-	
	Primary	-	-	
	Secondary	10	8.3	
	Tertiary	11	91.7	
Marital Status				
	Married	40	33.3	
	Single	49	40.8	
Sex				
	Male	80	66.7	
	Female	40	33.3	
Major Occupation				
	Farming	21	17.5	
	Trading	20	15.8	
	Civil service	19	15.8	
	Farming/trading	40	33.3	
Unemployment				
	1 – 2	60	50	
	3 – 4	10	8.3	
	5 years above	9	7.5	
Entrepreneurial Experience (yrs.)				
	0 – 5 yrs.	70	58.3	
	6 – 10 yrs.	10	8.3	**1.33**
	11 – 15 yrs.	10	8.3	
Nature Of Participation				
	Part – time	60	50	
	Full – time	20	16.7	**1.25**

Source: Field survey, 2018

Table 2: Level of participation in agricultural entrepreneurial activities in south-east EDC

Skills acquisition	Frequency	Percentage
Agriculture Forestry	20	16.7
Livestock Production	44	36.7
Beverage Production	-	-
Crop Production	22	18.3
Agro allied	6	5

Source: Field survey, 2018

Table 3: The Rate of Skills Acquisition in The Selected EDC's Program for South-East

Level of Participation	Total Score $\sum F\bar{x}$	Mean score $\bar{x}$	Std. Devi.
Agriculture Forestry	310.4	2.58**	1.60
Livestock production	332.2	2.77**	1.67
Beverage production	279.5	2.32*	1.52
Crop production	413	3.44**	1.84
Agro allied	258	2.15*	1.46
Grand mean score		**2.61****	
Bench mark mean score		**2.50**	

Source: Field survey, 2018 * represent low level of Participation ** represent high level of Participation

Table 4: Selected Socio-economic characteristic of Youths has no significant influence on Youth Participation in agricultural activities of EDC in the study areas, was tested using regression analysis

Variables	Mean	Std. devi.	Std. error Mean	D.F	z-value
Socio-economic characteristic of Youths.	2.31	2.36	0.56		
Youth Participation	2.61	2.60	0.82		
Difference	-0.3	-0.24	-0.26	119	-7.57

Source: Field survey, 2018 Tabulated value (2-tails) at 5% = 3.69 at 1% = 11.26

CONCLUSION

Since the mean age of the respondents was calculated and showed that they are in their youth and very productive, it can be stated that the majority of the respondents fell within the age range. The respondents' high level of education was evident in the fact that more men than women participated in the program's agricultural activities. The majority of young people in the study areas were unemployed for five years or longer, and most young people in the South-East EDC had zero to five years of entrepreneurial experience. It may be due to the lucrative nature of livestock and agricultural production, which offer returns on little money invested in it, that skills obtained in this sector were highly valued. Selected socioeconomic characteristics of youths have a considerable impact on youth participation in agricultural activities, according to the alternative hypothesis, which was approved. The investigation came to the conclusion that although youth in the south-east EDC receive training, money has not been given to them to launch their various agricultural businesses.

RECOMMENDATIONS.

The following recommendations where suggested:

- Given their strength and energy, unemployed youth in the South-East should be encouraged by providing loans so they can engage in agricultural enterprises.
- It is advised that EDC provide the youths with the appropriate incentives to increase their involvement in agricultural entrepreneurial activity. Facilitating land purchase for persons interested in crop production is one of these incentives.

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DETERMINANTS OF RURAL YOUTH PARTICIPATION IN CASSAVA PRODUCTION UNDER THE FEDERAL GOVERNMENT OF NIGERIA/INTERNATIONAL FUND FOR AGRICULTURAL DEVELOPMENT SUPPORTED VALUE CHAIN DEVELOPMENT PROGRAMME (FGN/IFAD-VCDP) IN NASARAWA STATE, NIGERIA

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ABSTRACT
Youth participation in agricultural activities is one of the major drivers of empowerment, job creation, income generation, and livelihood improvement through attainment of food security. The study was conducted to determine youth participation in cassava production under FGN/IFAD-VCDPin Nasarawa State, Nigeria. A multi-stage random sampling procedure was used in selecting 180 respondents for this study. A structured questionnaire was used to collect data from the respondents in the study area. Data were analyzed using both descriptive and inferential statistics. The variables of years of farming experience (t = 3. 329) and level of education (t = 2.057) were the socio-economic variables influencing youths participation in the programme in the study area. The challenges faced by respondents include weak distribution of inputs on time (80.0%), difficulty in raising funds for matching grant (69.2%) and inadequate inputs (60.0%). It was recommended that the programme and all other programmes including relevant institutions' should distribute inputs to youths at the right time, place, and quantity for timely agricultural production in the study area and youth farmers on the other hand should form cooperative groups and pool their resources together for easy access to funds for matching grant.
***Key words:** Determinants, participation, cassava production, rural youth, value change development programme*

INTRODUCTION
The Value Chain Development Programme (VCDP) was a six-year programme of the Federal Government of Nigeria funded by the International Fund for Agricultural Development (IFAD). The programme aims to improve income and food security of poor rural households engaged in production, processing and marketing of rice and cassava on a sustainable basis. VCDP was originally implemented in six states of Anambra, Benue, Ebonyi, Ogun, Niger and Taraba. Because of the programme success, VCDP received additional finance in 2021 for expansion into three states of Kogi, Nasarawa and Enugu making nine participating states (Sallawu *et al.*, 2019) .The goal of the programme is to reduce rural poverty, increase food security and accelerate economic growth on a sustainable basis (Sallawu *et al.*, 2019). In Nasarawa State, five (5) Local Government Areas of Lafia, Doma, Wamba, Karu and Nasarawa were selected for the implementation of the programme in 2021.
Cassava (*Manihot esculenta*) is a starchy root crop and a major source of food security in Africa because of its ability to grow in low quality soil, its resistance to drought and disease, and flexible cultivation cycle (Jirgi *et al.*, 2019). Cassava, which is rich in starch in the form of carbohydrate, has multiple uses. It is consumed in many processed forms, in the industry and as livestock feed (Oruonye *et al.*, 2021). Cassava production in Nigeria plays a crucial role in the country's agricultural sector and economy. Nigeria is the world's largest producer of cassava, with the crop serving as a vital staple food for millions of people (Oruonye *et al.*, 2021).
Youth in Nigeria are identified as all young males and females within the age bracket of 18-35 years, who are citizens of the Federal Republic of Nigeria (Nigerian National Youth Policy (NNYP), 2019). The definition by NNYP (2019) was adopted for this study. Participation is the act of working with others, making value judgments and determining causes of actions within a social situation or structure (Isa *et al.*, 2021).

This study holds considerable significance for various stakeholders, including policymakers, agricultural development agencies, and the youth population in Nasarawa State, Nigeria. By assessing youth participation in cassava production within the framework of IFAD-VCDP programmes, the findings of this research will provide a deeper understanding of the current dynamics and challenges faced by young individuals engaging in cassava production. The outcomes will aid policymakers and program implementers in designing more targeted strategies to increase youth involvement in the cassava value chain.

Problem statement

Youths' participation in cassava production can serve as a means of employment, source of income, provide food security for their families and reduce their poverty level. Youths are constrained in participating in agricultural activities by a host of challenges including limited access to productive assets and inputs; inadequate support services (extension); limited access to rural financial services; inadequate market and rural infrastructure; post-harvest losses and a constrained enabling environment (NBS, 2018). IFAD-VCDP in Nigeria deals in value chain activities of cassava and rice enterprises on a sustainable basis, which provides participants with inputs, capital supports, and adequate support services such as extension services, and adequate market for cassava and rice products. It is in recognition of the noble goals of the programme that the study assessed the determinants of youth participation in cassava production within the context of the IFAD-Value Chain Development Programme (VCDP) initiatives in Nasarawa State, Nigeria.

Objectives of the Study

The broad objective of the study was to determine youth participation in cassava production under FGN/IFAD-VCDP in Nasarawa State, Nigeria.

The specific objectives are to:

i. describe the socio-economic characteristics of the youths cassava farmers participating in VCDP in the study area;
ii. determine the effect of the socio-economic characteristics of youth cassava farmers' participation in the VCDP, and;
iii. identify the constraints to effective participation of youths cassava production in the VCDP in the study area.

METHODOLOGY

Study Area

The study was conducted in Nasarawa State, Nigeria. Nasarawa state is located within latitude: 7° and 9^0 N and longitude of 8^0 and 32^0 E. The state has a land mass of about 27,117km^2 (Wikipedia, 2022). The population of the study comprised all the 378 (Lafia 86, Doma 75, Wamba 68, Nasarawa 74 and Karu 75) registered youths participating in IFAD-VCDP cassava production in Nasarawa State. A multi-stage sampling technique was used to select respondents from the population for the study. In the first stage, a random selection of three (3) out of the five (5) participating LGAs in the state. The selected LGAs include: Lafia, Doma and Karu. In second stage, a purposive selection of 3 cassava enterprise communities known for participating in IFAD-VCDP in each of the three (3) LGAs selected. This gave 9 cassava enterprise communities that were used for the study. In stage three, a random selection of 50 percent of youths from the total youth population in each of the selected communities and this gave 116 youths that were used for the study. The data was obtained by the use of structured questionnaire administered to the respondents. Descriptive statistics such as percentage, frequency, mean and ranking order was used to analyze objectives 1 and 3. Multiple regression model was used to capture objective 2.

RESULTS AND DISCUSSION

Socio-economic Characteristics of Respondents in the Study Area

Sex: Table 1 shows the results of sex of respondents in the study area. Majority (86.2%) of the respondents were male while, 13.8% of the respondents were female. This implies that majority of the youth cassava farmers in the study area who participated in IFAD-VCDP were male. The high percentage of male youth cassava farmers maybe due to the fact that cassava production activities are generally strenuous and women may not be fit enough to carry out the operations hence the high gender disparity.

Level of Education: The results in Table1 reveals that 40.5% of the respondents had tertiary education, 20.7% and 16.4% of the respondents had secondary education and primary education respectively, while 22.4% of the respondents had no formal education. This implies that 75.0% of the youth cassava farmers had one form of education or another. The level of education attainment enables farmers to understand better the techniques involve in cassava production and adoption of improved cassava production technologies.

Farming Experience of the Respondents: The results in Table 1 also shows that marginal above half (51.7%) of the respondents had between 1 and 10 years of rice farming experience, while 26.7% had experience of between 11 and 20 years. Similarly, 21.6% of the respondents had experiences of 21years and above in cassava farming. The average cassava farming experience was computed at 15 years. This implies that youth cassava farmers participating in IFAD-VCDP were experience in cassava production in the study area. The years of experience provides the ability to understand production and to try other improved technologies while still ensuring the profitability of the enterprise.

Annual Income from Cassava Production of Respondents: Table 1 further shows that majority (88.8%) of the respondents had annual income of between ₦1,000 and ₦500,000, 7.8% had annual income of between ₦501,000 and ₦1,000,000; and 3.4% of the respondents had annual income of ₦1,001,000 and above. The mean annual cassava income of respondents in the study area was estimated at ₦313, 016. 67. This implies that youth cassava farmers earn low income annually in the study area. This would definitely drive poor households not to save more and therefore they require financial capacity to invest in technology adoption for improved production.

Table 1 Socio-economic Characteristics of Respondents in the Study Area

Variables	Frequency	Percentage	Mean
Sex			
Male	100	86.2	
Female	16	13.8	
Level of education			
No formal education	26	22.4	
Primary education	19	16.4	
Secondary education	24	20.7	
Tertiary education	47	40.5	
Years of farming experience (in years)			
1-10	60	51.7	**15 years**
11-20	31	26.7	
21 and above	25	21.6	
Annual income from cassava production (naira)			
1,000-500,000	103		**₦313,016.67**
501,000-1,000,000	9	88.8	
1,001,000 and above	4	7.8	
		3.4	
Total	**116**	**100**	

Source: Field survey, 2023

Determinants Effects of Socio-economic Variables Influencing Youths' Participation in Cassava Production under IFAD-VCDP in the Study Area

The result of the regression analysis as presented in Table 2 shows that the coefficient of determination (R^2) was 0. 365. This implies that 36.5% of the independent variables influenced the dependent variable. The variables of years of cassava production experience (t = 2. 329), and farm size (t = 2.057) exhibited positively significant relationship.

Years of Cassava Production Experience: The variable of years of cassava production experience was positive and significant at 5%. This implies that increase in years of cassava production experience in IFAD-VCDP will increase the probability of more participation by youth cassava farmers in the study area. This also implies that the more experience youth cassava farmers acquire in cassava production, the more the increase in knowledge, confidence and perfection level.

Farm Size

The coefficient of farm size was found to be positive and statistically significant at 5% level of significance. This means that as the farm size increases, the probability of cassava production under IFAD-VCDP will increase. Farm size has bearing on the capacity of farmers to possibly look for and adopt improved technologies and new farm practices and likely to devote more of their farmland for cassava production under IFAD-VCDP if they and sees they appreciate the volume of output/yield, returns, profitability, and availability of market.

Table 2: Determinants Effects of Socio-economic Variables Influencing Youths' Participation in Cassava Production under IFAD-VCDP in the Study Area

Variable	β- value	Standard error	t-value
Constant	1.424	.173	8.137
Age	21.999	35.447	.621
Level of education	-6.233	34.544	-.180
Years of experience in cassava production	.010	.004	2.329**
Farm size	202.853	98.633	2.057**
Household size	35.890	63.451	.566
Annual income	-3.569	24.850	-.144
Sex	-58.643	655.548	.304
Marital status	217.638	715.723	

Source: Field survey, 2023 ** = significant at 5% level of significance

Note: R^2 .365 (36.5%)

Dependent variable = Yield (kg/ha)

Challenges Faced by Respondents in the Study Area

Challenges faced by the youth cassava farmers are captured in Table 3 and it revealed that the respondents were faced with a number of challenges in the study area. These challenges include weak distribution of inputs on time, and space (80.0%), difficulty in raising funds for matching grant (69.2%), inadequate inputs (60.0%), inadequate equipment (27.5%), and tedious nature of some agronomic practices (15.0%). This shows that youth cassava farmers in the study area had challenges in terms of weak of distribution of inputs on time and space, difficulty in raising funds for matching grant and inadequate inputs in cassava production under IFAD-VCDP and may tend to discourage participation and expansion.

Table 3: Challenges Faced by Respondents in the Study Area

Challenge	Frequency	Percentage
Weak distribution of inputs on time and space	96	80.0
Difficulty in raising funds for matching grant	83	69.2
Inadequate inputs	72	60.0
Inadequate equipment	33	27.5
Tedious nature of some agronomic practices	18	15.0

Source: Field survey, 2023

Note: Less 40% = not serious challenge, 40%-69% = serious challenge, 70% above = very serious challenge

CONCLUSION

Based on the findings of the study, it can be concluded that years of cassava production experience and farm size were the socio-economic variables influencing youths' participation in cassava production under IFAD-VCDP in the study area. Weak distribution of inputs on time and space, difficulty in raising funds for matching grant, and inadequate inputs were some of the challenges faced by respondents in the study area.

RECOMMENDATIONS

Based on the findings of this study, it was recommended that;

i. IFAD-VCDP should distribute inputs to youth cassava farmers at the right time and space for timely cassava production in the study area.

ii. Youth cassava farmers should form cooperative groups and pool their resources together for easy access to funds for matching grant.

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ASSESSMENT OF RURAL YOUTH'S CHALLENGES WITHIN THE CASSAVA VALUE CHAIN IN EBONYI STATE, NIGERIA

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ABSTRACT
The study assessed rural youth's challenges within cassava value chain in Ebonyi state, Nigeria. Multi stage sampling technique was employed to sample and collect primary data from 120 respondents. Instrument used for data collection was structured interview schedule and Focus group discussion in twelve communities of the four LGAs selected for the study. Descriptive statistics such as percentage and mean scores were used for data analysis. The FGD was analyzed by transcribing responses of the discussants. The study revealed that the average age of the respondents was 31.6 years). They had average household size of 5 persons. They had average farming experience of 11 years. The Youth participated in most of the cassava value chain activities and they also encountered many challenges ranging from inadequate finance for cassava production, high cost farm labour, high cost of processing equipment, land tenure problem and inadequate and expensive transportation of products to the market as well as poor access to market information. It was recommended that credit facilities/loan should be provided to young farmers to enable purchase of farm inputs as well as processing equipment to add value to cassava value chain activities. There is also need for market information to enable off-takers come and purchase cassava in bulk which will benefit the farmers and reduce youth challenges in cassava value chain.

INTRODUCTION
Agriculture is a big industry that ought to attract a lot of young people, but due to the primitive methods employed in the field, most people see it as a job for the elderly, retirees and the aged in society (Attamah *et al*., 2023 & Bello *et al.,* 2021). For the majority of rural residents, agriculture is a source of employment and income. According to Osondu *et al*. (2023), in terms of area planted and total number of farmers engaged in its production, cassava (*Manihot* species) is the most well-liked and widely cultivated crop in Nigeria. Cassava is produced in Nigeria annually in excess of 54 million metric tons (MT) (FAOSTAT, 2021). The majority of the youngsters' activities are within the cassava value chain. Many people are directing the various branches of the government with little to no regard for the needs of the young. The youth are the group most impacted by these difficulties, and despite all the progress, this has caused great anxiety because it could have a negative impact on Nigeria's future. According to Oviawe (2010), continuous poverty, which is primarily observed among young people, is unquestionably the cause of the rising rates of crime, including armed robbery, advance fee fraud (419), corruption, prostitution, nepotism, drug trafficking, and other social vices.
Some scholars describe youth as the time in a person's life that occurs between the end of childhood and the beginning of adulthood. The person has reached adulthood, but he has not yet attained all of the responsibilities and rights that come with being an adult, such as getting married and providing for one's family and oneself (Onuekwusi, 2005). According to the United Nations definition, youth are defined as people under the age of 39 and beginning at 15 years old.
Nigeria is equipped with abundant natural and human resources, which can inspire young people to make significant contributions to agriculture and the growth of the country, particularly in the production of cassava. The youth currently make up roughly 60% of Nigeria's population and have significantly aided in national development over time (Vision 2010 report, 2005). To stimulate the interest of our youth in agricultural production, the government must put in place specific measures that will eliminate the associated constraints in the sector. Unfortunately, the current environment makes it even more difficult to explore their full potential in the industry. Youth participation in agricultural production has declined recently, particularly in rural regions (Koledoye and Olagunju, 2017).

Despite the rapidly expanding chances in this field, it is disturbing and pretty astounding to witness how many young people in rural areas are choosing to leave farming in favor of cities where there are no available white-collar employment, resulting in an unprecedented amount of rural-urban migration. Clearly, this poses a serious threat to the government's goal of achieving food security. Since they make up a larger portion of the workforce in agricultural production, youths play a significant role in agricultural growth, which merges with rural development (Odakara, 2005). However, they face several difficulties along the cassava value chain. According to Njoku (1999), these include the labor-intensive nature of agriculture due to the dependence on hand tools; investment practices in developing countries that typically discriminate against agriculture; the backwardness of the rural areas where farming activities predominate; and the lack of social amenities like electricity, good roads, pipe-borne water, transportation, schools, markets, hospitals, and communication facilities. The drab and boring way of life in rural areas that is linked to agriculture and, by extension, the cassava value chain presents a challenge for young people who are socially and fashionably minded.

Any nation that is devoted to sustainable agricultural and rural development policies may draw heavily on its youth population. Youths are heavily involved in all aspects of the cassava value chain in Ebonyi State, from land preparation to harvesting and processing to sale of both raw roots and finished cassava products. They deal with numerous well-known difficulties as well. However, it appears that there is a knowledge gap regarding the severity of the difficulties they face, which made the current study necessary. Therefore, the purpose of this study was to assess the difficulties faced by rural young people in rural areas in Ebonyi State's cassava value chain.

METHODOLOGY

This study was conducted in Ebonyi state. Multistage sampling technique was employed for the study. Two out of the three agricultural zones of Ebonyi state were used for the study, Ebonyi north and Ebonyi central. Two (2) Local Government Areas each in the two (2) Agricultural zones of the study area were selected to give a total of four LGAs selected. They are Ohaukwu and Izzi LGAs for Ebonyi North while for Ebonyi Central, Ishielu and Ezza north LGAs were selected. In the selected Local Government Areas, three (3) communities were purposively selected.The communities include: For Ohaukwu LGA, Ngbo, Ezzamgbo and Effium communities were selected, for Izzi LGA, Ndieze, Agbaja and Igbagu communities were selected,For Ishielu LGA, Nkalaha, Obeagu and Umuhuali communities were selected while for Ezza north LGA, Oshiegbe, Ndiaguazu and Umuogharu were selected.

Twelve (12) Communities were therefore selected to represent four (4) Local Government Areas in the two (2) agricultural zones selected for the study. Ten (10) youths from each community were systematically selected in twelve (12) communities giving a total of one hundred and twenty (120) respondents for the study. One focus group discussion was carried out in each of the LGAs selected for the study. Data was collected with the use of interview schedule and Focus group discussion. Analysis was done using descriptive statistics. FGD was analyzed by transcribing responses of the discussants.

RESULTS AND DISCUSSION

The results in Table 1 show the socio-economic characteristics of the respondents in the study area. From the data obtained majority (59.3%) of the respondents were males while 40.7% were females. This implies that gender distribution among youth farmers in Ebonyi State was dominated by males in cassava value chain. The study also revealed that 50% of the respondents were within the age range of 31-40 years while the average age was 31years. This implies that youth were actively engaged in activities of cassava value chain in the study area. The results also show that majority (59.3%) of the respondents were married, with average household size of 5 persons that encourages alternative source of labour *in-lieu* of hired labour. Educational status of respondents indicated that the respondents had varying levels of education were majority (91.5%) had formal education. This implies that majority of them were literate with average farming experience of eleven 11 years.

Respondents' annual income distribution indicated that their average annual income was ₦270,000.The implication of this result is that majority (84.7%) of the respondents earned between ₦200,000-₦400,000 annually which still indicated that they were low income earners.

Table 2 shows that inadequate finance for cassava production with a mean of (M=3.83) was the major challenge confronting the respondents. This is a big problem because finance is important to enhance access to farm inputs. Similarly, respondents identified high cost of farm labour and high cost of processing equipment as 2nd and 3rd challenges to cassava value chain with means of (M= 3.77) and (M= 3.72) respectively. With the rising cost of farm labour, rural farmers can hardly sustain their farming system. As a result of this, many famers use their family members mostly in activities like planting, fertilizer application and harvesting while the strenuous job will be done by hired labourers. This result is in conformity with the works of Churchill and Marisetty (2020) who discovered that capital is one of the major drivers of productive ventures globally. Land tenure system problem with mean (3.71) ranked 4th. Land tenure system in the study area was mainly by inheritance, it can be leased, individual owned or communally owned in the study area. Some land according to the respondents are mostly located in thick forest that is not developed then making it inaccessible, also some parents have sold off their land because of hardship or lost it on the process of using it as collateral for bank loan. Inadequate and expensive transport of products to the market with mean 3.65 and inadequate marketing information for products with mean 3.60 ranked 5th and 6th. constraints confronting youths in cassava value chain. Young rural farmers in Ebonyi state face additional constraints in accessing markets, market information can all facilitate youth's access to markets, with niche markets offering particularly significant opportunities for young farmers. Major marketing challenges that were common across communities included low prices for cassava produce on the market, lack of decent markets, and lack of adequate transport, including bad roads and accessibility. This position was supported by an FGD (2022).

A 22-year-old male farmer with the ambition to become a large-scale cassava farmer summarizes the marketing problem facing his community Nkalaha in Ishielu Local Government Area:

Firstly, we face the problem of transporting our farm produce from our villages here to the relevant destination (market locations). That is to say, the problem of the lack of road is the major problem. For instance, last year, I planted cassava and harvested, but sometimes what remained a problem was transporting it to the market. And secondly, the price in the market is too cheap considering the expenses involved from the beginning to the end of the season." Low and unstable produce prices, as well as challenges in finding buyers were the most mentioned marketing issues across communities in the Ebonyi state (FGD,2022)

In a similar response, a 24 year old female respondent in Agbaja community of Izzi Local Government Area stated thus:

Lack of market demand of what we have been able to produce" is a major challenge for a young man in Ndieze. Women in the Igbagu FGD believed the issue is that "there is no fixed price for commodities in this community." Another woman in umuoghara community in Ezza North Local Government Area believes that the problem is oversupply of their crops in accessible markets, forcing farmers to sell at cheaper rates. This is especially problematic with mobility restrictions (FGD, 2022).

A 27- year old female farmer with secondary school education in Ngbo community of Ohaukwu Local Government Area who finds it difficult to sell her produce notes:

We don't have buyers or markets for our farm produce. Sometimes you will do your farming activities, but you won't find the person who will buy the farm produce even if you carry it to the market." We lack off-takers who can buy our cassava in bulk (FGD, 2022).

Decline in soil fertility with mean 2.78 ranked 7th as one of the challenges confronting youth in cassava value chain activities in the study area. Respondents reported that when a piece of land is used for a long time without any form of soil fertility amendment practice like application of poultry manure, rice mill waste, animal dungs and compost manure, the nutrient in the soil will deplete thereby affecting the productivity of the crops. Also pest and diseases with mean 2.69 ranked 8th as another constraints to cassava value chain in the study area.

Lastly was inadequate extension visit with mean (2.18) ranked 10th this challenge is not seen as a major challenge in the study area because the youths are highly involved in all the activities involved in cassava value chain and do not place much value on the visit of extension personnel or agency.

CONCLUSION AND RECOMMENDATIONS

The study concluded that youth were involved in all activities along the cassava value chain in the study area. They also faced many challenges. Most especially inadequate finance for cassava production and high labour cost, high cost of processing equipment and land tenure system problem. All these problem areas must be looked into in order to encourage greater participation of youth in cassava value chain in the study area. There is need for provision of credit facilities/loan to enable farmers purchase inputs and processing equipment to add value to cassava There is also need for market information to enable farmers know where the demand is high to be able to sell their produce on time.

Table I: Socio-economic characteristics of the respondents

Variable	Frequency N= 118	Percentages (100)	Mean
Sex			
Male	70	59.3	
Female	48	40.7	
Age			
21-30	49	41.5	31.6
31-40	59	50	
41-50	10	8.5	
Marital Status			
Single	46	39.0	
Married	70	59.3	
Divorced	2	1.7	
Household size			
1-5	78	66.1	
6-10	38	32.2	5
11-15	2	1.7	

Level of Education			
No formal education	10	8.5	
Primary education	18	15.3	
Secondary education	55	46.6	
Tertiary education	35	29.7	
Farm experience			
1-5	11	9.3	11
6-10	49	41.5	
11-15	36	30.5	
16-20 &above	22	18.6	
Annual Income			
Less than ₦100,000	6	5.1	₦270,000
₦100,000-₦200,000	12	10.2	
₦201,000-₦300,000	53	44.9	
₦301,000-₦400,000	47	39.8	

Source: Field Survey, 2022

Table 2: Challenges of youth in cassava value chain

Challenges of youth in cassava value chain	Mean	Rank
Inadequate finance for cassava production	3.83	1st
High cost of farm labour	3.77	2nd
High cost of processing equipment	3.72	3rd
Problem of Land tenure system	3.71	4th
Inadequate and expensive transport of products to the market	3.65	5th
Inadequate marketing information for products	3.60	6th
Decline in soil fertility	2.78	7th
Pest and diseases problems	2.69	8th
Non accessibility of planting materials	2.33	9th
Inadequate extension visit/training of cassava farmers	2.18	10th

Source: Field Survey, 2022

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Federal University of Lafia, Nasarawa State.

"LAFIA"

SUB-THEME 5:

Biotechnology as a Panacea for Food Security

EVALUATION OF HIGH MICRO-NUTRIENT SWEET POTATO GENOTYPES FOR SOME AGRONOMIC TRAIT

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ABSTRACT

Micro-nutrients especially vitamin A, Iron and Zinc are essential to the healthy well being of man and animals. However, most staple food crops like sweet potato are low in these essential nutrients. Base on this, a trial was conducted at the western experimental field of National Root Crops Research Institute, Umudike Umuahia, Abia State with the aim to generate botanical seeds for evaluation for high micro-nutrient density progenies, to increase the genetic base of sweet potato genotypes enabling screening for high micro-nutrient density progenies and to select seeds with heavy weight which will ensure good germination during evaluation for micronutrient density progenies. The ten parents were planted 30cm within row and 100cm between rows in a plot size measuring 3m x 3m in an RCBD design with 3 replications. Data collected were on total number of capsules harvested, total number of seeds harvested, total number of good seeds, percentage number of the good seeds extracted, weight of 100 seeds per parent. Data collected were subjected to Analysis of Variance and means were separated using Standard error (SE±)). Results obtained indicated that 3638 healthy botanical seeds were generated for progeny evaluation and selection for micro-nutrient dense genotypes. The seeds realized will increased the sweet potato genetic base for screening for high nutrient dense progenies. Seeds with heavy weights should be considered for next generation seedling evaluation for micro-nutrient dense progenies. The varieties with heavy seed weight were NRSP/AYT/19/805, NRSP/AYT/19/420 and NRSP/AYT/19/603 with weight 769g, 648g and 550g, respectively These three parents could be included in future generation advance for micro-nutrient dense progenies.

Keyword: *Sweet potato, micronutrients, seed weight, botanical seeds and progeny.*

INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) is well known as nutritious food. It is cultivated as annual crop due to its capacity to produce storage root at a shorter period of 3.5 to 4 months unlike cassava a root crop and yam a tuber crop that matures in 10 and 7 months respectively depending on the variety. Sweet potato is a rich source of proteins, minerals and vitamins for human nutrition. Sweet potato foliage and roots are also a valued animal feed. Today, sweet potato is an important food eaten with rice and other food products, used in making bread, doughnuts, cakes and juice. In fact the crop plays an important role in human and animal health improvement. Sweet potato is grown in every part of the country with a particular concentration in the northern part of the country due to its short growing period of 4 months using the available short season rainfall in that area. Currently, there has been renewed interest at national and international levels to enhance the nutrient content in our foods. One of the approach is to develop nutrient-dense cultivars in our staple foods. In this endeavour, the first step is to characterize the genetic diversity for nutrient content that exists in current cultivars and genotypes, and use the information in breeding for high micro-nutrient genotypes. ICARDA (2007) reported a preliminary screening of 645 maize accessions comprised of breeding lines, land-races and released cultivars with iron (Fe) content varied from 41 to 132 mg/ kg and zinc (Zn) content ranged from 22 to 78 mg/kg, which suggest scope of improvement of these traits through plant breeding. The most commonly grown improved sweet potato cultivars are also being crossed with micronutrient-dense accessions to enrich the progenies with higher micronutrients. The high content sweet potato lines are being crossed to develop transgressive segregants with even higher contents of micronutrients. For example, parents with an Fe content of 60 mg/kg are being used to develop progenies with an Fe content of >60 mg/kg. Similarly, high Zn content accessions are included in a crossing block to develop progenies high in Zn. Nutrient-dense sweet potato varieties could provide marketing opportunities for producers, baby food industrialists and others thereby increasing sales. An additional benefit to farmers is that under some soil conditions (e.g. low mineral availability), nutrient-dense cultivars have the potential to improve seedling establishment and resistance to certain diseases (ICARDA, 2007). Due to the escalating costs to purchase micro-nutrient capsules from Pharmaceutical shops, and an increasingly nutritious conscious consumer society, has collectively given a brighter future for a highly nutritious food produced by hybridization without fear of intragenic. The new progenies realized from crosses are predicted to have high micro-nutrients and could be adapted to the farming systems of the people for sustainability (ICARDA, 2007). Adequate variability for many of the sweet potato genetic constraints exists within the crop gene pool allowing manipulation through breeding. However, several other important traits such as biomass yield, resistant to sweet potato virus disease (SPVD), micronutrients are not currently addressable by breeding because of insufficient genetic variation for such traits. Within an agro-ecological zone, traits may provide benefits for adaptation over large areas such as with water stress in some soils. Flowering time in sweet potato is important for adaptation as it determines the length of the vegetative phase and determines the climatic conditions that the crop will be exposed to during reproductive growth. Sweet potato genotypes that adapted to rainy season flower late and produce few capsules than during dry season because reproductive development begins when conditions are increasingly hot and dry.

According to Wera et al (2014). Correlations between traits must be given careful consideration during crossing block establishment. This is because number of capsules per plant, number of seeds per capsule, secondary lateral branches per plant and vine length have significant positive correlation with number of botanical seeds produced by the sweet potato plant. However, number of capsules to reach maturity are the most important characters that contribute positively to botanical seed yield. Early maturing sweet potato parent plants having early growth vigour and a greater number of capsules should be selected for short season environments, as they will be able to escape terminal dry season stresses. Semi-spreading cultivars such as UMUSPO/1 and TIS8164 are grown under normal but late sown situations, have stable botanical seed yields because the plants are able to fill the available space by initiating lateral branches and compensating for poor emergence if any. Early flowering combined with early growth, vigour and early maturity leads to, large seeds which are some of the desirable attributes of a plant (Ratna et al, 2019), for crops under late sown conditions. In sweet potato, it is easy to create genetic variation via hybridization because this species is generally self-incompatible, so seeds do not develop from self-fertilization. The choice for parents was focused mainly on flowering ability, storage root flesh colour, and storage root yield. All flesh colours as well as genotypes with high, and low yield were planted as parents. In this study recurrent mass selection in an open pollinated block was used with the following objectives: to generate botanical seeds for evaluation for high micro-nutrient density progenies, to increase the genetic base of sweet potato genotypes enabling screening for selection for high micro-nutrient density progenies and to select seeds with heavy weight which will ensure good germination during evaluation for micronutrient density progenies.

MATERIALS AND METHODS

The trial was conducted at the western experimental field of National Root Crops Research Institute, Umudike Umuahia, Abia State in the rainforest agro-ecology of Southeastern Nigeria. The site for the experiment was a hydromorphic soil which was slashed, ploughed, harrowed and ridged. The area was then divided into plots and the plots were grouped into blocks. The 8 parents were recurrent selection which comprised current breeding lines at AYT (Advance Yield Trial stage) and two released varieties (UMUSPO/3, and TIS8164) were also included as parents totaled ten parents and were planted on the crest of the ridges 30cm within row and 100cm between rows in a plot size measuring 3m x 3m and replicated three times which gave a total of 30 plots which was fitted in the Randomized Complete Block Design (RCBD) with 3 replications. The trial was established in 15th of September 2022. Sweet potato is grown in Nigeria as a rainy season crop and mostly under rain fed conditions in areas where scanty rainfall is frequently observed. However, the crop is planted in September to experience terminal drought. This will force the sweet potato (to maturity through flower production.

The plots were not staked. The crop were allowed to spread on the soil surface to act as live mulch to conserve soil moisture because of the nature of the soil which is a hydromorphic soil. The whole plots were kept weed free throughout the trial. The parents were subjected to polycross for generating open-pollinated seeds under natural setting (Degrass, 2003). The dried capsules when turned brown while on the parents were regularly harvested, sun dried for at least one week, then, threshed, packed in well labeled envelope and stored in a glass container. All seeds collected from each of the parents were packed in a well labeled envelope.

No fertilizer was applied to prevent the crop from growing too luxuriantly and delay flowering. The following data were collected: total number of capsules harvested per parent, total number of seeds harvested per parent, total number of good seeds, percentage number of the good seeds extracted, weight of 100 seeds per parent.

Data collected were subjected to Analysis of Variance and means were separated using Standard error of difference (S.E.D).

RESULTS AND DISCUSSION

The major characteristics of parents used in the crossing block are presented in Table 1.

Table 1: Sweet potato Used as Parents in the Crossing Block and their major traits

Name	Origin	Status	Flowering habit	Skin colour	Flesh colour
NRSP/AYT/19/420	Nigeria	Breeding lines	Moderate	Red	White
NRSP/AYT/19/490	Nigeria	breeding lines	Sparse	White	Cream
NRSP/AYT/19/851	Nigeria	breeding lines	Profuse	purple	Deep orange
NRSP/AYT/19/603	Nigeria	breeding lines	Sparse	White	White
NRSP/AYT/19/805	Nigeria	breeding lines	Profuse	Orange	Dark orange
NRSP/AYT/19/852	Nigeria	breeding line	Sparse	purple	Pale orange
NRSP/AYT/19/6O1	Nigeria	breeding line	Profuse	Cream	Pale orange
NRSP/AYT/19/5211	Nigeria	breeding lines	profuse	pink	orange
TIS8164	Nigeria	released	Profuse	Cream	Pale orange
UMUSPO/3	Nigeria	Released	profuse	brown	deep orange

Three of the parents were of cream/white fleshed colour while seven of the parents were of pale orange, orange and deep orange.

Table 2: Results of the number of capsules and botanical seeds

Parents	Total number of capsules	Total number of seeds collected per parent	Number of good seeds collected per parent	% Good seeds collected	Number of bad seeds	Weight of 100 seeds per Parent (g)
NRSP/AYT/19/420	401	618	512	14.1	106	648
NRSP/AYT/19/490	223	512	482	13.2	30	191
NRSP/AYT/19/851	131	342	214	5.9	128	261
NRSP/AYT/19/603	269	431	328	9.0	103	550
NRSP/AYT/19/805	113	226	206	5.7	20	769
NRSP/AYT/19/852	431	532	492	13.5	40	344
NRSP/AYT/19/6O1	211	338	301	8.3	37	266
NRSP/AYT/19/5211	151	387	322	8.9	65	244
TIS8164	221	434	368	10.1	66	309
UMUSPO/3	262	473	413	11.4	60	309
Total	**2413**	**4293**	**3638**	**100**	**655**	**3891**
Mean	**241.3**	**429.3**	**363.8**	**10.0**	**65.5**	**389.1**
Range	113-431	226-532	206-512	=	=	=???
SED	16.4	21.8	=	=	=	=???
Sig. level	P<0.01	P<0.01	=	=	=	=???

Total number of capsules collected: The total number of capsules collected was 2413 with mean of 241.3. The number of capsules produced by the parents varied significantly ($P<0.01$) from 113 (NRSP/AYT/19/805) to as high as 431 (NRSP/AYT/19/852. Number of seeds per capsules varied from one to four. However, more number of seeds are obtained per capsules when parents are allowed to inter-mate under natural conditions. That is when pollinating agents such as insects are allowed to do the pollination. This is because in search for nectar, insects constantly visited a flower and in that process more pollen are deposited on the stigma resulting into many seeds per capsules. Capsules obtained under controlled crosses do not contain as many seeds per capsules. Parents with more number of capsules showed that it flowered profusely and will produce large quantity of seeds.

Total number of seeds: The total number of botanical seeds produced by the sweet potato plants was 4293 with mean of 429.3 seeds. The number of seeds produced by the parents varied significantly ($P<0.01$) from 226 for NRSP/AYT/19/805 to as large as 512 as produced by NRSP/AYT/19/852. The parent with the highest number of seeds was NRSP/AYT/19/420 with 612 seeds followed by the parent NRSP/AYT/19/490 with 512 seeds. While the least seed production was from the parent NRSP/AYT/19/805 with 226 seeds of the total number of seeds produced. Parent with high number of seed production indicated that it could be constituted in the breeding block for progeny production. However, number of seeds produced depended on the number of good quality seeds. Most Sweet potato seeds are susceptible to pest injury and unfilled as a result of other mechanical and genetic problems.

Number of good seeds: Number of good seeds generated was 3638 with mean of 363.8 which was 10% of the total number of seeds produced by the parents. Number of sorted good botanical seeds ranged from 206 to 512 seeds. However, the parent with the highest number of healthy botanical seeds was NRSP/AYT/19/420 with 512 seeds which accounted for 14.1%, followed by NRSP/AYT.19/852 with 492 seeds which represented 13.5% while the least was NRSP/AYT/19/805 with 206 seeds which accounted for 5.7% of total number of good seed produced. Seeds are materials for genetic transfer.

Good quality botanical sweetpotato seeds are foundation for good sweetpotato progeny development and their products. Good quality botanical seeds were for the evolution and introduction of high yielding sweetpotato varieties (Rahman, 2018, Ratna et al 2019). The productivity of sweetpotato can be increased by the farmers by using quality good botanical seeds which were evaluated and selected for superior performance in terms of yield and other desirable attributes. The country will have high potentials to grow wide varieties of sweetpotato if botanical seeds were readily available for field evaluation and suitable genotypes are made available for different agro-climatic conditions ranging from rainy to dry seasons (Purchase, 2000).

Total number of bad/defected seeds was 655 with mean of 65.5 defected seeds. The Parents with the highest number of bad seeds was NRSP/AYT/19/851 with 128 bad seeds, followed by NRSP/AYT/19/420 with 106 bad seeds while the least was NRSP/AYT/19/805 with 20 bad seeds. Bad/defected seeds means loss of genetic factor. The sweetpotato defected botanical seeds produced were affected by a number of factors ranging from inherent genetic incompatibility among the varieties, climatic factors when there were not enough soil moisture to enable the seeds to fill up, to entomological problems when insects feeds on the botanical seeds creating hole and destroying the botanical seeds. All these factors affect the transfer of genetic material of the parents to progenies for new varietal development. Anything that may lead to loss of genetic factor must be avoided.

Seed weight: Hundred seeds were taken from each family and weighed, NRSP/AYT/19/805, although had the least number of produced seeds, had the heaviest seed weight of 769g followed by NRSP/AYT/19/420 with 648g, while the least seed weight was obtained from NRSP/AYT/19/5211 with 244g and a general mean of seed weight of 389.1g. Seed weight is a measure of high percentage of germinability and survivability of the crop into seedlings. It contributed in seedling vigour and speed of growth as a result of the reserved food. Seed weight is the first indication that the seed is alive and contributes to the productivity of the crop at harvest. Seeds that has low weight should be especially taken care of to ensure its survivability especially if the variety has the traits that are highly sort for by end users. They should be given enough nutrients to increase their vigour and survivability.

CONCLUSION

Total of 3638 healthy botanical seeds were generated for progeny evaluation and selection for micro-nutrient dense genotypes. The seeds realized will increased the sweet potato genetic base for screening for high nutrient dense progenies. NRSP/AYT/19/805 with weight 769g, NRSP/AYT/19/420 which weighed 648g and NRSP/AYT/19/603 with weight 550g were identified and recommended for 2023 nursery evaluation. These three parents could also be included in future hybridization block for future botanical seed production.

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EVALUATION OF NEWLY DEVELOPED SWEETPOTATO GENOTYPES AT PRELIMINARY YIELD STAGE FOR HIGH STORAGE ROOT YIELD AND MARKET ACCEPTABILITY TRAITS

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ABSTRACT
This study was conducted at the Western farm of National Root Crops Research Institute Umudike, Abia State, Southeastern Nigeria with the aim to select genotypes with high number of storage root per plant, storage root size above 100g, genotypes free from biotic stresses and to select genotypes with marketable attributes such as: smooth skin and appealing storage root flesh colour. Data were collected and analyzed with ANOVA. Results obtained indicated that Genotypes selected for having high yielding potential was PYT/21/075 with 7.0 number of storage roots per 1000 plants per hectare while the least was PYT/21/040 and PYT/21/028 with 0.5 storage roots per 1000 plants per hectare respectively. These genotypes have storage root size of above 100g, they were also free from cracks, oxidation and possess unique flesh colour that appeals to the eye which accounts for good marketable attributes. Genotypes with number of storage roots higher than the two check varieties UMUSPO/3 and TIS78/0087 would be advanced to the next stage of evaluation- Advance Yield Trial.
Keywords: *Storage root, root size, number of roots per stand, marketable attributes and preliminary yield.*

INTRODUCTION

Sweet potato although can grow in marginal soil but is also sensitive to poor soil deficient in soil nutrients. The productivity of sweet potato_in Sub-Sahara Africa (SSA) are still remarkably low, with an average of 6 t/ha compared to 13 t/ha in South America, 22 t/ha in China, and 25 t/ha in Northern America (FAOSTAT, 2019). Average of sweet potato root yields are 8t/ha in East Africa, 7.5t/ha in Central Africa, 3t/ha in South Africa, and 3t/ha in West Africa, respectively (FAOSTAT, 2019), which are far below attainable yield levels. Attainable yield is defined as the mean on-farm yield plus three times the standard deviation (Van Vugt and Franke, 2018). Attainable root yields in experimental farms under rainfed conditions were from 18 to 32t/ha among districts in Malawi (Van Vugt and Franke, 2018), 25–29t/ha in South Africa (Laurie et al., 2017), 27t/ha in Mozambique (Andrade *et al*., 2017), and 39t/ha in Nigeria (Uwah *et a*l., 2013). Moreover, the productivity of sweet potato in African countries of Uganda, Nigeria, Tanzania, Angola, Burundi, Mozambique, Madagascar, Rwanda, Ethiopia, Kenya and Cameroon is very low (< 10 t/ha), and hence improvement in the yield traits of sweet potato is of prime importance to plant breeders (Andrade *et al*., 2016; Rukundo *et al*., 2013). Other causes of low storage root yield in sweet potato are pathogenic and entomological stresses.

Sweet potato virus disease (SPVD) are widespread diseases inflicting serious yield losses across the country and are also of economic importance. Among insects, weevil (*Cylas* spp.) is an important field pest which causes serious losses of storage roots in the field during dry spell. These stresses appear individually and/or in combination with varying intensity depending on the location, season and year, thus, causing great fluctuation in sweet potato roots and vine production in the country. Hence, development of resistant varieties against major diseases and realizing the yield potential of existing commercial cultivars are being given priority towards breaking yield barriers in sweet potato breeding. The scope of selection for desirable sweet potato genotypes depends on the extent of exploitable genetic variability. Some of the promising traits in the indigenous gene pool are early maturity and more number of storage roots and /or cluster of roots per plant stand. Sweet potato genotypes have been reported to mature within 4 months and are considered to be short season crop.

The average yield of sweet potato in Nigeria is 6t/ha which is 86% lower than the world average (46t/ha) (FAOSTAT, 2019). The reasons for low yield are occurrence of various biotic, abiotic and edaphic factors at different growth stages. Being a rainy season crop, sweet potato is grown on conserved soil moisture during the rainy season. As a result, soil water deficit during crop establishment and storage root bulking emerges as the

major yield constraint along with the rising temperature leading to field pests' infestation. Soil nutrients deficiencies are also observed locally in most sweet potato growing zones. Sweet potato virus disease complex are widespread diseases inflicting serious yield losses across the country. Fungal diseases such as *alternaria* leaf blight disease and leafspot are also of economic importance.
Among Insects such as storage root weevil, aphid and Cylass *species* is an important field pest. These stresses appear individually and/or in combination with varying intensity depending on the location and year and time in the year, thus, causing great fluctuation in sweet potato production in the country. Hence, development of high yielding genotypes with resistance against major diseases and to realize the yield potential for commercial cultivars should be given priority. This could be done towards breaking yield barriers in sweet potato development. However, the aim of this study was to select genotypes with high number of storage root per plant, storage root size above 100g, genotypes free from biotic stresses and to select genotypes with marketable attributes such as: smooth skin and appealing storage root flesh colour.

MATERIAL AND METHODS

The experiment was conducted at the Western farm of the NRCRI Umudike**.** Land was prepared by first slashing the area, ploughed, harrowed before ridging. The area was marked into three blocks and each block was subdivided into plots with each plot measuring 3 x 1m, which was $3m^2$ per plot. The 104 sweetpotato genotypes selected from clonal evaluation were evaluated at PYT stage using 4 nodes seed cuttings from symptomless mother plant. Each varietal line were planted per plot and replicated three times. The planting spacing was 1.0 x 0.3m within plot and 1.0m between plots. This gave a total of 312 plots. The experimental design used was RCBD. Inorganic fertilizer NPK 15:15:15 was applied at four weeks after planting to enable the plants to express its storage root yield potential. Manual weeding was done at 4 weeks after planting and rouging was carried out at 8 weeks after planting until harvest. Standard check varieties used were UMUSPO/3 and TIS 87/0087.
Data were collected on:, mean number of storage root per genotype per $6m^2$, mean number of storage root per stand, mean weight of fresh storage root in t/ha and size of storage root.

Data on marketable attributes collected were on;

(a) **Size of storage root**: The largest root from each genotype was weighed.
(b) **Oxidation in storage root flesh**: The freshly harvested storage root was cut in cross section and the surface was allowed to come in contact with the fresh air. The amount of browning is observed within 5 to 10 seconds and rated as follows: 1 = no browning, 2 = very little browning, 3 = little browning, 4 = moderately browning, 5 = abundant browning
(c) **Storage root cracking**: Ten plants were selected for observation of cracks on the storage roots. The average of the ten plants were scored using the following scale: 1= no cracks, 2= very few cracks, 3 = moderate cracks, 4 = medium cracks, 5 = many cracks.
(d) **Entomological reactions:** Storage root weevil infestation severity rating using Scoring scale 1 to 5. Where, 1 = no symptom, 2= symptom present, 3= symptom mild, 4= symptom severe, 5= symptom very severe.

Data collected were subjected to analysis of variance and Mean separation was done using **standard error of means.**

RESULTS AND DISCUSSION

The results of the storage root yield characteristics and Marketable storage root attributes of the PYT sweetpotato genotypes evaluated are presented in Table 1.The yield data of the genotypes were sorted in order from the least to the greatest. The arrangement splits the yield data into two equal halves with 50% of the data below the median and 50% above the median. The yield data from the middle value to the greatest value is presented in Table 1.

Table 1: Storage root yield characteristics and Marketable storage root attributes of the PYT sweetpotato genotypes evaluated

Name of clone	Stand count at harvest	Mean total number of storage roots per $3m^2$	Number storage roots per plant /1000/plants/ha	Weight of total storage root (t/ha)	Weight of largest storage root (g)
PYT/21/075	2	14	**7.0**	4.2	122.0
PYT/21/079	4	13	3.3	5.1	114.7
PYT/21/026	6	13	3.3	3.5	136.0
PYT/21/034	4	13	3.3	5.1	124.7
PYT/21/095	3	10	3.3	3.5	166.0
PYT/21/044	5	15	3.0	4.1	135.7
PYT/21/014	7	20	2.9	5.7	164.6
PYT/21/078	5	14	2.8	5.5	123.0
PYT/21/007	5	14	2.8	5.6	145.5
PYT/21/056	3	8	2.7	2.5	108.0

PYT/21/076	6	15	2.5	5.1	140.0
PYT/21/093	4	10	2.5	2.7	114.5
PYT/21/048	4	10	2.5	1.4	155.7
PYT/21/029	4	10	2.5	2.8	144.5
PYT/21/084	5	12	2.4	4.3	121.4
PYT/21/020	5	12	2.4	3.3	123.3
PYT/21/023	8	18	2.3	2.6	125.0
PYT/21/014	9	14	2.3	2.6	125.0
PYT/21/024	6	14	2.3	3.0	154.9
PYT/21/073	4	9	2.3	3.5	120.0
PYT/21/004	6	13	2.2	3.4	155.7
PYT/21/005	6	13	2.2	3.2	123.0
PYT/21/070	5	11	2.2	3.3	128.0
PYT/21/062	5	11	2.2	4.5	105.4
PYT/21/042	5	11	2.2	4.3	153.3
PYT/21/022	7	15	2.1	4.1	125.7
PYT/21/031	4	10	2.1	1.7	124.5
PYT/21/015	6	12	2.0	4.5	143.0
PYT/21/064	4	8	2.0	3.1	130.0
PYT/21/096	8	15	1.9	4.2	160.0
PYT/21/008	7	13	1.9	5.0	133.1
PYT/21/053	7	13	1.9	3.5	129.0
PYT/21/025	6	11	1.8	4.2	122.5
PYT/21/030	4	11	1.8	3.7	133.0
PYT/21/009	6	11	1.8	2.5	166.0
UMUSPO/3	4	7	**1.8**	**2.3**	102.4
PYT/21/041	7	12	1.7	4.0	164.9
PYT/21/018	4	15	1.6	3.1	135.7
PYT21/100	7	11	1.6	3.7	123.0
Tis87/0087	6	9	**1.5**	**2.2**	122.4
PYT/21/002	9	13	1.4	4.3	183.3
PYT/21/028	7	10	1.4	3.6	141.0
PYT/21/003	11	14	1.3	3.0	174.9
PYT/21/033	7	9	1.3	2.5	134.1
PYT/21/019	6	8	1.3	2.2	143.5
PYT/21/008	9	10	1.1	3.0	164.0
PYT1/21/099	8	9	1.1	4.6	121.0
PYT/21/090	4	3	0.8	3.6	124.4
PYT/21/040	6	11	0.5	3.2	168.5
PYT/21/028	6	3	0.5	1.4	165.7
Mean	6.0	11.3	2.2	3.7	134.9
Range	3-11	3 – 20	0.5-7.0	1.4-5.7	102.4-183.3
S.E	2.5	3.4	1.4	1.9	11.8
CV%	41.0	36.2	28.4	32.1	22.6

Note; PYT= Preliminary Yield Trial

Number of storage roots per plant: The number of storage roots per plant per every 1000 plants per hectare ranged from 0.5 to 7.0 with mean of 2.2 number of storage roots per stand, and with coefficient of variation of 28.4%. This percentage of coefficient of variation presented huge genetic variability to select large number of genotypes with high number of storage roots per stand. The genotypes with the highest number of storage root per stand was PYT/21/075 with 7.0 number of storage roots followed by PYT/21/095 with 3.3 number of storage roots per stand per every 1000 plants per hectare. These two genotypes produced more number of storage roots higher than the two check varieties- TIS87/0087 with 1.5 and UMUSPO/3 with 1.8 number of storage roots per stand. The genotypes that produced very low number of storage roots per stand was PYT/21/028 with 0.5 number of storage roots per stand per 1000 plants per hectare.

Fresh weight of storage roots: This was the fresh weight of the storage roots. The weight of the fresh storage roots varied from 1.4 to 5.7t/ha with coefficient variation of 32.1% which indicated a huge genetic variability for selection. The genotype that gave the highest fresh storage root weight was PYT/21/014 with 5.7t/ha followed by PYT/21/007 with 5.6t/ha while the genotypes that gave the lowest fresh matter yield were PYT/21/048 and PYT/21/028 with 1.4t/ha respectively. All these yields are too low when compared with other regions. FAOSTAT (2019) reported of fresh storage root yield gap in Sub-Sahara Africa (SSA) that average yield in SSA are still low 6t/ha compared to South America which is 13t/ha, China 22t/ha to North America 25t/ha. The yield gap between average yields in SSA on small holder farms in South Africa 60 to 80t/ha is huge (Low *et al* 2020). According to Jones *et al* (1986), organic and inorganic fertilizer should be used as a synergistic component of crop improvement programme through breeding. In other words, crops should be assisted to reach its genetic potentials. He advised the Crop Improvement Programmes to depend largely on the scope and efficiency of breeding work and fertilizer use. A good knowledge of the crop characteristics and nutritional requirements is necessary also the crop environment which would transform the inherent crop genetics characteristics into desirable qualities for increased yield and growth performance. The desired genetic potentials of crops can only be fully expressed under adequate and balanced plant nutrition. The medium of growth of improved crop varieties accounts for over 95% of the factors of productivity of the crops. It is requirements therefore imperative that breeding programmes should be backed up with full knowledge of the crops nutrition. Plant nutrients such as organic and inorganic fertilizers should be supplied to crops under improvement at the right time and condition and should not be supplied arbitrary but should be punctuated to elicit optimum performance of the improved variety.

Size of storage roots of genotypes: The largest storage root yield per genotype was weighed. Any storage root that weighed above 100g is regarded as commercial root (Loebenstein and Thottappilly, 2009; Degrass, 1998). The storage root sizes of the genotypes ranged from 102.4 to as heavy as 183.3g with mean of 134.9g. The genotype with the heaviest marketable attributes was PYT/21/002 with weight of heaviest root of 183.3g followed by PYT21/003 with weight of heaviest storage root of 174.9g while the genotype with the least heavy root of 102.4g was UMUSPO/3. The single storage root weight from each of the genotype was heavier than that of the check varieties. The check variety TIS87/0087 with one of its largest root weighed 122.4 and another check variety UMUSPO/3 had its largest root that weighed 102.4g. This indicated that the genotypes produces storage root sizes which were of marketable root attributes.

Entomological reactions and other Storage root marketable attributes of the PYT sweetpotato genotypes: The entomological reactions and other Storage root marketable attributes of the PYT sweetpotato genotypes evaluated are presented in Table 2.

Table 2: Entomological reactions and other Storage root marketable attributes of the PYT sweetpotato genotypes evaluated

Name of clone	Weevil severity scale 1 to 5	Skin colour	Flesh colour	Cracks of storage roots scale 1 to 5	Storage flesh oxidation scale 1 to 5
PYT/21/014	1.3	C	C	1.0	1.0
PYT/21/023	1.0	C	C	1.0	2.0
PYT/21/076	1.0	Y	O	1.0	1.0
PYT/21/096	1.2	W	C	1.0	1.0
PYT/21/022	1.0	Y	C	1.0	1.0
PYT/21/044	1.0	P	C	1.0	1.0
PYT/21/018	1.0	P	PO	1.0	1.0
PYT/21/075	1.0	Y	C	1.0	1.0
PYT/21/078	1.4	P	Y	1.0	1.0
PYT/21/003	1.5	O	DO	1.0	1.0
PYT/21/007	1.5	P	O	1.0	1.0
PYT/21/014	1.0	C	C	1.0	1.0
PYT/21/024	1.0	O	IO	1.0	1.0
PYT/21/079	1.3	P	PY	1.0	1.0

PYT/21/002	1.2	O	O	1.0	1.0
PYT/21/008	1.2	P	DO	1.0	1.0
PYT/21/053	1.0	C	C	1.0	1.0
PYT/21/026	1.2	W	W	1.0	1.0
PYT/21/034	1.0	P	Y	1.0	1.0
PYT/21/004	1.0	Y	PY	1.0	1.0
PYT/21/005	1.0	W	O	1.0	1.0
PYT/21/084	1.0	C	C	1.0	1.0
PYT/21/041	1.5	P	DO	1.0	1.0
PYT/21/015	1.0	P	O	1.0	1.0
PYT/21/020	1.2	O	O	1.0	1.0
PYT/21/070	1.0	Y	Y	1.0	1.0
PYT21/100	1.0	W	C	1.0	2.0
PYT/21/040	1.5	P	W	1.0	1.0
PYT/21/062	1.0	W	C	1.0	1.0
PYT/21/025	1.0	w	PO	1.0	1.0
PYT/21/042	1.2	O	O	1.0	1.0
PYT/21/030	1.0	W	C	1.0	1.0
PYT/21/009	1.0	W	W	1.0	1.0
PYT/21/008	2.1	W	Y	1.0	1.0
PYT/21/095	1.2	W	W	1.0	1.0
PYT/21/093	1.0	C	DY	1.0	1.0
PYT/21/048	1.0	Y	PY	1.0	1.0
PYT/21/031	1.0	C	Y	1.0	1.0
PYT/21/028	1.0	P	C	1.0	1.0
PYT/21/029	1.0	C	Y	1.0	1.0
PYT/21/073	1.0	W	C	1.0	1.0
PYT1/21/099	1.0	W	C	1.0	1.0
PYT/21/033	1.3	C	PO	1.0	1.0
Tis87/0087	1.3	P	C	1.0	1.0
PYT/21/019	1.0	Y	DC	1.0	1.0
PYT/21/056	1.0	C	C	1.0	1.0
PYT/21/064	1.0	C	Y	1.0	1.0
UMUSPO/3	1.0	O	O	1.0	1.0
PYT/21/028	1.0	Y	Y	1.0	1.0
PYT/21/090	1.0	W	C	1.0	1.0
Mean	**1.2**	=	=	**1.0**	**1.1**
Range	**1.0-1.5**	=	=	**1.0-1.0**	**1.0-2.0**

Note: PO = pale orange, IO = intermediate orange, DO = dark orange, PY = pale yellow, DY = dark yellow, DC=dark cream, O = Orange, Y = Yellow, W = White, C = Cream

Entomological reaction: The entomological reactions of the PYT genotypes indicated that the only pest present at the time of harvest was the storage root weevil *Cylas ponticollis.* The severity score ranged from 1.0 to 1.5 with mean of 1.2. This showed that most of the genotypes were not attacked at the time of harvest. This confirms the advice of many researchers that sweetpotato genotypes should not be allowed to stay more than necessary in the soil especially in storage root weevil prone areas, plan not to harvest during hot dry spell, cover cracks properly with sod during storage root bulking and avoid hydromorphic soils (Schalk and Jones, 1985).

Storage rook skin colour: The PYT sweetpotato genotypes have wide range of skin colours from cream, white, pink, orange to brown. Although, white/cream colour attracts to the eye, it has no special contribution to the quality of the flesh storage roots. However, skin colour is an array of choice for various consumers roaming the markets.

Storage root flesh colour: There were various storage root flesh colour segregation due to gene reshuffling. The colours are of various intensity ranging from cream to white and pale white, to white, orange to dark orange, pale yellow to yellow and deep yellow. The more pale the lower the intensity of the colour and the lower the beta-carotene. The consumers has array of sweetpotato flesh colour to choose from. However, majority of the consumers prefer white flesh colour to other colours.

CONCLUSION

Farmers and breeders priority for any new crop is higher yield. However, breeders are unsatisfied with the yield of any current crop and continued to develop new varieties to be superior to the existing ones. Reason being that any new clonally propagated plant breakdown every seven years due to accumulation of diseases. Genotypes selected for having high yielding potential was PYT/21/075 with 7.0 number of storage roots per 1000 plants per hectare while the least was PYT/21/040 and PYT/21/028 with 0.5 storage roots per 1000 plants per hectare respectively. These genotypes have storage root size of above 100g, they were also free from cracks, oxidation and possess unique flesh colour that appeals to the eye which accounts for good marketable attributes. However, genotypes with number of storage roots higher than the two check varieties UMUSPO/3 and TIS78/0087 would be advanced to the next stage of evaluation Advance Yield Trial.

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COMPARATIVE ANALYSIS OF EFFECT OF USE OF IMPROVED SWEET POTATO PRODUCTION TECHNOLOGIES BY FARMERS IN SOUTH-EAST, NIGERIA

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ABSTRACT
This study analyzed the effect of use of improved sweet potato production technologies by farmers in South–East, Nigeria. Multi-stage and proportionate sampling methods were used to collect data for the study. Three States, namely Abia, Anambra and Ebonyi States were purposively selected, two agricultural zones were randomly selected from each of the States to give a total of six (6) zones, two (2) blocks were randomly selected from each of the zones to give a total of twelve (12) blocks, finally, proportionate sampling technique was used to select farmers from the circles to give a sample size of 364 sweet potato farmers. List of sweet potato farmers from sweet potato farmers' association, Abia State, Extension Services Programme office of NRCRI Igbariam outstation, Anambra State and Sweet potato farmers' association, Ebonyi State served as the sampling frame. Data for this study were collected using structured questionnaire and analyzed using descriptive statistics such as frequency, percentages, meanwhile inferential statistics used was ANOVA. Result showed that majority (72.25%) of the farmers were females while few (27.75%) were males, the mean of annual income was ₦579,395.6. Good number (69.23%) of the farmers had farm sizes of less than 1 hectare (0.1-0.9 ha). The result also revealed that 47.25% and 26.37% of the farmers participated always and often respectively in the farmers' association where they belong. The farmers' roots yield before use of improved sweet potato production technologies was mean of 14,795.30 kg/ha, while farmers' root yield after use of improved sweet potato production technologies was mean of 28,511.92 kg/ha. This result showed that use of improved sweet potato production technologies has greatly increased the yield of sweet potato root. The F-value (117.900) obtained from ANOVA result showed significant difference (P< 0.05) in root yield produced across the States. The study concluded that there was significant difference in sweet potato root yield across the States and there was also difference in sweet potato root yield before and after utilization of improved sweet potato production technologies disseminated to farmers in South-East, Nigeria. Therefore, it is recommended that sweet potato farmers should use the improved sweet potato production technologies disseminated to them for increased root yield.
Keywords: *Farmers, Use, Improved Sweet potato, Production Technologies*

INTRODUCTION
Sweet potato (*Ipomoea batata* (L) Lam) is an important tropical staple food crop, belonging to the morning-glory family known as *convolulaceae* and is originated from Latin America. Nigeria is the third largest producer of sweet potato in the world with china leading, followed by Uganda (FAO, 2004). Sweet potato is mainly propagated by vine-cuttings, planted on mounds and ridges and in single or double rows. The best yields occur in areas with 750 to 1,000 millimeters of annual precipitation, with at least 500 mm falling during the growth season. However, sweet potatoes do not grow well in water logged soil as it may cause tuber rots and reduce storage roots if aeration is poor (Mbanaso *et al.*, 2012). It can be cultivated twice a year (i.e. April to August and August to December (Ehisianya *et al.*, 2014). In general, planting takes place from February through July in the central and south, where rainfall is heavier. But planting along rivers in the central part of the country or swampy areas in the north can extend the planting season from September to December. Sweet potatoes are often intercropped as the secondary or minor crop.
Sweet potato is an important food security crop in Nigeria and Africa at large, and it is known as the crop that is there when the maize fails (Jia, 2013). Sweet potato leaves have added nutritional value, with greater amounts of protein and crude fiber. The leaves, skin and tender shoots of sweet potato are also eaten and are very nutritious. One hundred grams of fresh sweet potato leaves contain more iron, vitamin C, folates, vitamin K, and potassium.

The roots have high level of carbohydrates for daily energy production. Sweet potatoes are appropriated for meeting the nutritional needs of malnourished children and elderly populations who need high-energy foods that are also suitable for small stomachs. The crop is grown for multipurpose, its roots and vines are used both for human food and for animal feed. Sweet potato is used in a variety of ways for food, feed and processed products such as bread, ready-to-eat breakfast, French fries, syrup, starch and beverages (Walker *et al.,* 2014). It can be eaten boiled, baked or fried and can be sliced, sun-dried, used for the production of chips which are sometimes ground into flour. The dry matter content of sweet potato is one of the important traits that influence its acceptability, of which processing industries require high dry matter greater than 30%, also high quality starch. Besides carbohydrates, it is a rich source of protein, lipid, calcium and carotene. It is good source of carbohydrate as well as raw material for the manufacturing of industrial starch, glucose and alcohol (Udo *et al.,* 2005). Sweet potato production technologies such as improved sweet potato varieties, sweet potato intercropping, land preparation methods, vine cutting (3 and 4nodes), plant spacing (30cm x 30cm), planting time, use of herbicide, weeding regime (1^{st} and 2^{nd}), use of fertilizer, earthing-up (mean), use of insecticide and proper harvesting time. have been developed and disseminated in South-East Zone of Nigeria, but there is still dearth of information on the effect of use of the production technologies on root yield in the study area. Hence the study on comparative analysis of effect of use of improved sweet potato production technologies by farmers in South-East, Nigeria. Specific objectives of the study are: to describe the socio-economic characteristics of the farmers; estimate farmers' root yield before and after use of improved sweet potato production technologies disseminated; and ascertain the difference in root yield across the States.

METHODOLOGY

The study was conducted in South-East, Nigeria. Multi-stage and proportionate sampling methods were used to collect data for the study. Three States, namely Abia, Anambra and Ebonyi States were purposively selected, two agricultural zones were randomly selected from each of the States to give a total of six (6) zones, two (2) blocks were randomly selected from each of the zones to give a total of twelve (12) blocks, finally, proportionate sampling technique was used to select farmers from the circles to give a sample size of 364 sweet potato farmers. List of sweet potato farmers from sweet potato farmers' association, Abia State, Extension Services Programme office of NRCRI Igbariam outstation, Anambra State and Sweet potato farmers' association, Ebonyi State served as the sampling frame. Data for this study were collected using structured questionnaire. Data were analyzed using descriptive such as frequency, percentages, meanwhile inferential statistics used was ANOVA (Duncan Multiple Range).

Duncan multiple range test model is as follows:

$DMRP = QP\sqrt{MSE/r}$

Where

DMRP = Duncan Multiple Range

QP = Shortest Significant Range

$\sqrt{MSE}$ = Mean Square Error

r = Number of States.

RESULTS AND DISCUSSION

Table 1 result shows that majority (72.25%) of the farmers were females while few (27.75%) were males. This result implies that female folk were involved in sweet potato farming more than their male counterparts. The finding is in agreement with (Anyaegbunam *et al*., 2019) who reported in their study that sweet potato are traditionally viewed as women crop, grown predominantly by women farmers. The mean of annual income was ₦579,395.6. This implies that the farmers' income was low. Good number (69.23%) of the farmers had farm sizes of less than 1 hectare (0.1-0.9 ha). This result reveals that the sweet potato farmers were small holder farmers. The result corroborates that of Abudu *et al.* (2014) who reported that majority of farmers in the South-East Nigeria were small scale farmers, on the average cultivate less than 2 hectares of land. The result also shows that 43.68% of the respondents had farming experience of 6-10years, indicating that the farmers had enough farming experience on sweet potato farming. According to Arimi (2014), who opined that higher number of years of experience in farming help farmers in use of technology. The results also revealed that 47.25% and 26.37% of the farmers participated always and often respectively in the farmers' association where they belong. Few of the farmers (18.13%) and (8.24%) represent those who participated sometimes and never respectively in the community association. This result indicates that the farmers participated in the activities of the association where they belong.

Table 1: Distribution of farmers according to their socioeconomic characteristics

Variables	Abia (n=64)	Anambra (n=99)	Ebonyi (n=201)	South-East Pooled (n=364)	Mean
Sex					
Male	18(28.13)	31(31.31)	52(25.87)	101(27.75)	
Female	46(71.87)	68(68.68)	149(74.13)	263(72.25)	

Annual income					
₦10,000-200,000	5(7.81)	8(8.08)	15(7.46)	28(7.69)	
₦210,000-400,000	10(15.62)	18(18.18)	46(22.89)	74(20.33)	
₦410,000-600,000	20(31.25)	22(12.12)	49(24.38)	91(25.00)	**₦579,395.6**
₦610,000-800,000	16(25.00)	31(31.31)	52(22.89)	99((27.12)	
₦810,000-1,000,000	13(20.31)	18(18.18)	41(20.39)	72(19.78)	
Farm size					
0.1-0.9	52(81.25)	69(69.69)	131(65.17)	252(69.23)	**0.6ha**
1-1.9ha	9(14.06)	24(24.24)	59(29.35)	92(25.27)	
2- 2.9ha	3(4.69)	6(6.06)	11(5.47)	20(5.50)	
Farming experience					
1-5	19(29.69)	15(15.15)	25(12.44)	59(16.21)	
6-10	30(46.88)	45(45.45)	84(41.79)	159(43.68)	**10.6 years**
11-15	11(17.19)	28(28.28)	76(37.81)	115(31.59)	
16-20	3(4.69)	7(7.07)	9(4.45)	19(5.21)	
21-25	1(1.56)	2(2.02)	5(2.49)	8(2.20)	
26-30	0(0.00)	2(2.02)	2(1.00)	4(1.10)	
Participation in farmers association					
Always	38(59.38)	60(29.85)	74(36.82)	172(47.25)	
Often	26(40.62)	29(14.42)	41(20.39)	96(26.37)	
Sometimes	0(0.00)	7(3.48)	59(29.35)	66(18.13)	
Never	0(0.00)	3(1.49)	27(13.43)	30(8.24)	
Total				**364**	

Source: Field Survey, 2021 Figures in parenthesis are percentages.

Estimated farmers' root yield before and after use of improved sweet potato production technologies

Table 2 shows the farmers' root yield before and after use of improved sweet potato production technologies disseminated. The farmers' sweet potato roots yield before use of improved sweet potato production technologies was mean of 14,795.30 kg/ha, while farmers' sweet potato root yield after use of improved sweet potato production technologies was mean of 28,511.92 kg/ha. The difference was 13,716.62kg/ha. This result shows that use of improved sweet potato production technologies has greatly increased the yield of sweet potato roots. This is in agreement with Guneberg *et al.* (2015) that progress in yield can be achieved by breeding through replacing old varieties with new varieties.

Table 2. Estimated farmers' root yield before and after use of improved sweet potato production technologies

Source of Variation	Abia (n=64) $\bar{X}$	Anambra (n= 99) $\bar{X}$	Ebonyi (n=201) $\bar{X}$	South-East (n=364) Pooled $\bar{X}$ root yield (kg/ha)
Root yield before	14,002.15kg/ha	14,427.50kg/ha	15,956.25kg/ha	14,795.30 kg/ha
Root yield after use of improved sweet potato production technologies	27,589.16kg/ha	28,123.10kg/ha	29,823.50kg/ha	28,511.92 kg/ha
Difference	13,587.01kg/ha	13,695.6kg/ha	13867.25kg/ha	13,716.62kg/ha

Source: Field Survey, 2021

Analysis of Variance Showing the Significant Difference in Sweet potato Root Yield across the States

The F-value (117.900) obtained from Analysis of Variance shows significant difference ($P< 0.05$) in root yield produced across the States. The post hoc result shows that there was significant difference in sweet potato root produced cross the States (Abia, Anambra and Ebony). This implies that across the three States, sweet potato root yield produce by farmers were of different quantities. This finding agrees with Birhanu *et al.* (2014) who reported in their study that an environmental condition resulting from variation amount of temperature, soil fertility, moisture and other factors may be the cause of difference in root yield of sweet potato in different locations.

Table 3: Analysis of variance showing the difference in sweet potato root yield by the farmers across the States

Source of variation	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	4566663944473.53	2	2283331972236.767	117.900	0.000
Within Groups	6991379371481.13	361	19366701860.059		
Total	1155804331595.67	363			

Post Hoc Test

Duncan

		Subset for alpha = 0.05		
		Abia	**Anambra**	**Ebonyi**
Ebonyi	201	28997.2637[a]		
Anambra	99		196222.2222[b]	
Abia	64			310921.8750[c]

Source: Field Survey 2021

CONCLUSION AND RECOMMENDATION

The study concluded that there was significant difference in sweet potato root yield across the States. Also, there was difference in sweet potato root yield after use of improved sweet potato production technologies dissemination in the study States. Therefore, it is recommended that sweet potato farmers should use the improved sweet potato production technologies disseminated to them for increased root yield.

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HARNESSING THE ROLE OF BIOTECHNOLOGY ON FOOD AND NUTRITIONAL SECURITY FOR SUSTAINABLE AGRICULTURAL DEVELOPMENT IN NIGERIA

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ABSTRACT
The role of biotechnology in addressing food and nutritional security has become increasingly significant for the sustainability of agriculture in the globe of which Nigeria is not an exception. With the growing global population, limited access to arable land and climate change challenges, it is highly imperative to explore and adopt biotechnology as innovative approach to enhance agricultural productivity that will enhance access to safe and nutritious food. Biotechnology also offers promising solutions by leveraging the understanding of genetic and molecular mechanisms in plants, animals, and microorganisms. The involvement and adoption of biotechnology will help to leverage the food insecurity and thereby promote a hunger free Nigeria. Therefore, this article is an attempt to review the prospects and challenges of implementing biotechnology in Nigeria to enhance food and nutritional security.
Keywords: *Biotechnology, Nutritional food Security and Sustainable Agricultural Development*

INTRODUCTION
In recent years, the global population has been steadily increasing, leading to greater demands for food and nutritional security. This challenge is particularly significant in developing countries like Nigeria, where agricultural practices often struggle to keep pace with population growth. However, biotechnology has emerged as a powerful tool to enhance agricultural productivity, improve crop yields, and address the issues of food and nutritional security (Ajeigbe *et al.,* 2019). By harnessing the potential of biotechnology, Nigeria can achieve sustainable agriculture and ensure an adequate and nutritious food supply for its population. Biotechnology encompasses a range of techniques and technologies that involve the use of living organisms or their components to develop beneficial products and processes. In the context of agriculture, biotechnology offers various applications, including genetic engineering, tissue culture, marker-assisted breeding, and bioinformatics. These tools enable scientists and researchers to modify crops for improved resistance to pests and diseases, enhanced nutrient content, increased yield potential, and better adaptation to environmental stresses (Nweke *et al.,* 2019, Falusi *et al.,* 2020). Biotechnology has facilitated the development of genetically engineered crops with built-in pest and disease resistance traits. By reducing crop losses due to pests and diseases, farmers can produce more food with fewer inputs, contributing to improved food security (Qaim,2016). By leveraging biotechnology, Nigeria can overcome many of the challenges it faces in the agricultural sector, such as low crop productivity, post-harvest losses, and inadequate access to nutritious food (FAO, 2008; Ojo *et al*., 2020).
Biotechnology enables biofortification, a process of increasing the nutrient content of food crops through conventional breeding or genetic engineering. This approach has been used to enhance the levels of iron, zinc, vitamin A, and other essential nutrients in staple crops like rice, wheat, and maize. Biofortification offers a sustainable and cost-effective strategy to improve the nutritional status of vulnerable populations (Bouis and Saltzman, 2017). Biotechnology offers tools to develop crops with enhanced resistance against diseases and pests. By introducing genes conferring resistance into crop plants, biotechnology can reduce the reliance on chemical pesticides, making agricultural practices more sustainable and environmentally friendly (Crossa *et al.*, 2017). This approach can contribute to increased crop yield and reduced post-harvest losses caused by diseases and pests. Biotechnology also plays a role in enhancing nutritional security in the aquaculture sector. Genetic improvement programs for farmed fish and shellfish aim to develop breeds that grow faster, are disease-resistant, and have better nutritional profiles. Some of these biotechnology tools like selective breeding, genetic engineering, and genomics assist in achieving these goals, supporting sustainable aquaculture production and food security (Hellberg and Morrrissey, 2007; Parvez *et al.*, 2021).

In spite of the potentials of biotechnology in leveraging food and nutritional security in Nigeria, its adoption is still untapped. Therefore, it is imperative to create more public awareness to address safety concerns, risk assessments, ethical considerations, potential environmental impacts accompanied by proper regulatory frameworks. By harnessing the potential of biotechnology, Nigeria can achieve sustainable agriculture and ensure an adequate and nutritious food supply for its population, and overcome many of the challenges it faces in the agricultural sector, such as low crop productivity, post-harvest losses, and inadequate access to nutritious food. Overall, biotechnology plays a vital role in promoting sustainable agriculture, enhancing crop productivity, improving nutritional quality, and ensuring food security in Nigeria. More, so by integrating biotechnology into agricultural practices, Nigeria can now achieve long-term food and nutritional security goals while mitigating the challenges posed by climate change, pests, and diseases. This paper therefore, reviewed the role and challenges of biotechnology on food and nutritional security for sustainable agricultural development in Nigeria.

METHODOLOGY

Secondary data was used to elicit information from textbooks, journals, proceedings, guides bulletins and some national dailies.

RESULTS AND DISCUSSION

Biotechnology and Agricultural Transformation:

Improved crop varieties: Biotechnology enables the development of genetically modified (GM) crops with enhanced traits such as resistance to pests, diseases, and environmental stresses. These crops can withstand harsh conditions, produce higher yields, and have improved nutritional content. For example, GM crops like insect-resistant cotton and pest-resistant cowpea (beans), yellow root cassava and orange fleshed sweet potato fortified with beta carotene have been developed in Nigeria to combat yield losses and increase nutrition and productivity (Paine *et al*., 2005).

Disease and pest control: Biotechnology offers tools to manage crop diseases and pests through techniques like genetic engineering can introduce genes into crops to confer resistance against specific pathogens or insects. This reduces the reliance on chemical pesticides and promotes environmentally friendly pest management practices.

Crop adaptation: Climate change poses a significant threat to agricultural productivity. Biotechnology can contribute to developing climate-smart crops that are resilient to changing climatic conditions, including drought, heat, and salinity. By enhancing the adaptive capacity of crops, biotechnology helps ensure a more stable food supply (Qaim, 2016).

Nutritional enhancement: Biotechnology enables the development of crops with improved nutritional profiles, addressing nutrient deficiencies in diets. For instance, biofortification techniques can enhance the nutritional content of staple crops such as rice, maize, and cassava by increasing the levels of essential vitamins and minerals. This helps combat malnutrition and improves public health (Bouis and Saltzman, 2017).

Disease resistance in livestock: Biotechnology can also contribute to livestock health and productivity. Genetic improvement techniques can enhance disease resistance in livestock, improving overall animal health and reducing economic losses. For instance, biotechnology can be used to develop vaccines and diagnostic tools for livestock diseases prevalent in Nigeria. (Onyimba *et al.,* 2020).

Sustainable agriculture practices: Biotechnology facilitates the adoption of sustainable agricultural practices. By reducing the need for chemical inputs, such as pesticides and fertilizers, it helps minimize environmental pollution and preserve biodiversity. Biotechnology can also contribute to reducing post-harvest losses through the development of crops with improved shelf life and resistance to spoilage.

Capacity building and knowledge transfer: Harnessing biotechnology for food and nutritional security requires skilled personnel and institutional capacity. Efforts should be made to invest in research and development, provide training programs, and promote knowledge transfer to ensure the effective and responsible use of biotechnology in agriculture (Okeniyi *et al.,* 2021).

Challenges of Biotechnology

Biotechnology has immense potential to contribute to food and nutritional security in sustainable agriculture. However, it also presents several challenges that need to be addressed.

Public perception and acceptance: Biotechnology, particularly genetically modified organisms (GMOs), has faced public concerns regarding safety, environmental impact, and ethics. To overcome this challenge, it is crucial to enhance public awareness and understanding of biotechnology through effective communication and transparent information sharing. Engaging with stakeholders, including consumers, farmers, scientists, and policymakers, can help build trust and create a supportive environment for biotechnological advancements.

Regulatory frameworks: The development and commercialization of biotech products are subject to stringent regulatory frameworks in many countries. While regulations ensure safety and environmental protection, they can also slow down innovation and make the approval process lengthy and expensive. Governments and regulatory bodies should strive to establish science-based and streamlined regulatory systems that foster innovation while addressing safety concerns.

Intellectual property rights (IPR): Intellectual property protection is crucial for incentivizing investment in biotechnology research and development. However, IPR issues can sometimes hinder access to biotech tools and technologies for small-scale farmers in developing countries. Encouraging technology transfer, promoting licensing agreements, and ensuring fair and equitable benefit-sharing mechanisms can help address IPR challenges and ensure access to biotechnology for all.

Capacity building and infrastructure: Biotechnology requires skilled scientists, technicians, and infrastructure for research, development, and implementation. Building technical capacity, particularly in developing countries, through training programs, knowledge sharing, and infrastructure development is vital. Collaborative efforts between developed and developing countries, international organizations, and academia can support capacity building initiatives and promote technology adoption.

Environmental impacts: Biotechnology should be implemented with careful consideration of its potential environmental impacts. The release of genetically modified organisms into the environment must be accompanied by rigorous risk assessments to ensure minimal ecological disruption. Promoting sustainable farming practices, such as integrated pest management, precision agriculture, and conservation agriculture, can complement biotechnology approaches and minimize environmental risks.

Socioeconomic equity: Biotechnology has the potential to address food and nutritional security, but its benefits must be accessible to all farmers, regardless of their scale of operation or location. Ensuring equitable access to biotech products, technologies, and knowledge, particularly for small-scale farmers, can help bridge the socioeconomic divide and promote sustainable agriculture on a broader scale (Ojo *et al.*, 2020).

CONCLUSION

Biotechnology plays a vital role in promoting sustainable agriculture, enhancing crop productivity, improving nutritional quality, and ensuring food security in Nigeria. By integrating biotechnology into agricultural practices, Nigeria can achieve long-term food and nutritional security goals while mitigating the challenges posed by climate change, pests, and diseases.

RECOMMENDATIONS

The way forward, food and nutritional security for sustainable agriculture lies in embracing biotechnology as a tool; while addressing the associated challenges.

i. More public awareness to address safety concerns, risk assessments, ethical considerations and potential environmental impacts accompanied by proper regulatory frameworks.

ii. Collaborative efforts among scientists, policymakers, farmers, consumers, and other stakeholders are crucial to creating an enabling environment that promotes responsible and inclusive biotechnological innovation for a more sustainable and food-secure in Nigeria.

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EVALUATION OF ADVANCED WHITE YAM GENOTYPES (*D. ROTUNDATA*) FOR GROWTH AND YIELD IN UMUDIKE SOUTH-EASTERN NIGERIA.

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ABSTRACT
Field experiment were conducted at Umudike a rainforest agro ecological zone of South-Eastern Nigeria during the 2022 and 2023 cropping seasons tomto study the evaluation of advanced white yam genotypes (D. rotundata) for the growth and yield. The experiment was laid out as a 4 x 5 factorial in a randomized complete block design (RCBD) with three replicates. The treatments were 20 genotypes of white yams. The high number of tuber per plant of the advanced white yam could be obtained from TDr1439027 genotype and the highest tuber yield could be obtained from genotype TDr0900061 and is recommended.
Key words: *Advanced white yam, genotype, growth, yield, southeastern Nigeria.*

INTRODUCTION
Yam plants are monocotyledons which belongs to the genus *Dioscorea* and family *Dioscoreaceae* . Out of the 600 cultivars of yam recorded, only six species are important and staple food in the tropics. These include white yam (*D. rotundata*), yellow yam (*D. cayenensis),* water yam (*D. alata*), trifoliate yam (*D. dumentorum*), aerial yam (*D. bulbifera*) and Chinese yam (*D. esculenta*). (Asiedu, 2010) (*D. rotundata*) is a native to West Africa, and the yam of preference in the region. Its cultivation has spread to other parts of the world including the Caribbean, Asia, and South America (FAOSTAT, 2020). In West Africa, yams are major source of income and have high cultivated values, being celebrated in the annual new yam festivals and used in marriage ceremonies. The tuber is the edible portion of yam and has high carbohydrate content, serving as a major source of energy but, low in fat and protein. Yam is consumed as boiled yam, pounded yam and fried yam or processed into flour. Several genotypes of white yam have been developed, but farmer requires information on the performance of the genotypes in various agro-ecological zones. The objective of this study was to evaluate advanced white yam genotypes for their growth and yield in Umudike southeastern Nigeria

MATERIALS AND METHODS
The field trial was conducted at the farm of the National Root Crops Research Institute (NRCRI), Umudike, South Eastern Nigeria in 2022 and 2023. The field was prepared by slashing, ploughed and harrowed. The field was marked out into three replications and each replicate was divided in to 20 plots measuring 4m x5m (20m^2). The spacing between each replicate was 1m and the spacing between each plot was 0.5m. The sett size was 100g of 20 different genotypes of white yam were the experimental treatments. The experiment was a Randomized Complete Block Design (RCBD) with three replications. Data were collected on the following growth parameters: vine length, vine girth, leaf area, leaf area index, at 3 and 4 months after planting. Yield parameters recorded were number of tubers per plant, weight of tubers per plant and tuber yield in t/ha. Data were analyzed using Genstat Statistical package.

RESULTS AND DISCUSSION
Growth and Yield characteristics
At 3MAP, genotype TDr 09/00082 had significantly longer vines than TDr5, Obiaturugo and TDr1428017 but not others (Table 1). However, at 4MAP, TDr 1440035 had significantly longest vine.
Generally, vines were thickest (girth) in genotypes Obiaturugo (1.9mm) and TDr89/02664 (1.7mm) and others compared to TDr1436015, TDr1429027, TDr1439027 and TDr1428017 at 3MAP (Table 2). At 4MAP, thickest stem were obtained from Obiaturugo (3.3mm) and TDr1401593 (3.0mm) while thinnest vines were from TDr1439027 (1.1mm), TDr1436015 (1.2mm), TDr000021 (1.6mm) and TDr1429027 (1.7mm).

The number of leaves per plant at 3MAP was significantly highest in TDr000078 (254) and TDr09/00082 (249) but lowest in TDr1436015, TDr1439018 and TDr1440035 (Table 3). At 4MAP however, the greatest number of leaves was obtained from TDr1439027 while the least was from TDr1440035 and TDr1401593.

The number of tubers per plant and tuber yield varied significantly with the white yam genotypes (Table 4). The number of tubers produced per plant ranged from 0.92 in TDr1439018 to 3.98 in TDr1439027.Genotypes TDr1429027, TDr1439027, TDr11/00396 and TDr1401593 produced significantly highest number of tubers (3.1 - 4.0). The highest tuber yield was obtained from genotypes TDr0900061 (2.6t/ha), followed by TDr89/02665 (1.7t/ha), and TDr11/00396 or TDr000078 (1.4t/ha) in that order. Generally, the low yields obtained were due to low weight of tuber per plant.

CONCLUSION

From the study, it appeared that the high number of tuber per plant of the advanced white yam could be obtained from TDr1439027 genotype and the highest tuber yield could be obtained from genotype TDr0900061.

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Table 1: Effect of white yam genotypes on plant height (cm) at 3 and 4 MAP.

Genotypes	3MAP	4MAP
TDr1439018	80.9	143.0
TDr000021	91.2	107.0
TDr0900061	112.1	133.0
TDr1414005	115.4	124.0
TDr1440035	79.4	32099.0
TDr1436015	40.4	120.0
TDr11/00585	87.8	109.0
TDr1417015	83.9	120.0
TDr/00003	105.2	125.0
TDr11/000078	86.9	149.0
TDr11/00396	99.8	110.0
TDr89/02665	98.0	148.0
TDr09/00082	126.9	119.0
TDr1430007	91.4	100.0
TDr1429027	82.7	102.0
TDr1439027	76.6	137.0
TDrObiaturugo	61.1	74.0
TDr0000360	100.0	135.0
TDr1428017	42.9	88.0
TDr1401593	71.6	79.0
LSD$_{(0.05)}$	48.2	20511.3

Table 2: Effect of white yam genotypes on vine girth (mm) at 3 and 4MAP.

Genotypes	3MAP	4MAP
TDr1439018	0.793	2.140
TDr000021	1.032	1.620
TDr0900061	1.083	2.410
TDr1414005	0.887	2.430
TDr1440035	0.793	2.410
TDr1436015	0.670	1.160
TDr11/00585	1.557	2.620
TDr1417015	0.987	2.580
TDr/00003	0.977	2.320
TDr11/000078	0.993	2.330
TDr11/00396	1.297	2.430
TDr89/02665	1.663	2.770
TDr09/00082	1.143	2.640

TDr1430007	1.093	2.150
TDr1429027	0.537	1.690
TDr1439027	0.430	1.080
TDrObiaturugo	1.867	3.320
TDr0000360	1.310	2.050
TDr1428017	0.667	2.160
TDr1401593	1.317	3.030
LSD($_{0.05}$)	0.921	1.521

Table 3: Effect of white yam genotypes on leaf number at 3 and 4 MAP.

Genotypes	3MAP	4MAP
TDr1439018	52.0	100.8
TDr000021	117.0	108.7
TDr0900061	161.0	150.0
TDr1414005	175.0	116.2
TDr1440035	55.0	64.4
TDr1436015	40.0	102.1
TDr11/00585	98.0	129.9
TDr1417015	75.0	114.2
TDr/00003	160.0	156.6
TDr11/000078	254.0	169.2
TDr11/00396	154.0	101.0
TDr89/02665	185.0	150.0
TDr09/00082	249.0	131.4
TDr1430007	139.0	103.6
TDr1429027	64.0	76.3
TDr1439027	120.0	181.7
TDrObiaturugo	64.0	92.2
TDr0000360	164.0	103.6
TDr1428017	69.0	75.2
TDr1401593	145.0	67.9
LSD($_{0.05}$)	137.8	73.0

Table 4: Number of tubers per plant and tuber yield (t/ha) of twenty white yam genotypes in 2022.

Genotypes	**Number of tuber/plant**	**Tuber yield (t/ha)**
TDr1439018	0.92	0.62
TDr000021	2.54	1.00
TDr0900061	1.41	2.55
TDr1414005	1.60	0.90
TDr1440035	1.14	0.20
TDr1436015	1.00	0.07
TDr11/00585	1.43	0.93
TDr1417015	1.36	0.22
TDr/00003	2.71	0.88
TDr11/000078	2.14	1.38
TDr11/00396	3.18	1.40
TDr89/02665	1.69	1.65
TDr09/00082	1.73	0.62
TDr1430007	2.54	0.67
TDr1429027	3.98	0.48
TDr1439027	3.89	0.22
TDrObiaturugo	1.53	0.22
TDr0000360	1.71	1.03
TDr1428017	1.42	0.08
TDr1401593	3.14	1.32
LSD($_{0.05}$)	1.41	0.72

LIVELIHOODS AND SUSTAINABILITY PRACTICES ON BIOTECHNOLOGY AS A PANACEA FOR FOOD SECURITY IN NASARAWA STATE, NIGERIA

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ABSTRACT
Food production is not keeping pace with the rapidly increasing population, and Biotechnology is one of the ways to increase productivity and gradually attain food security .This study evaluated the effects of livelihoods and sustainability practices on biotechnology as panacea for food security in Nasarawa State, Nigeria. Multistage sampling method was employed to select 210 small-scale food crop producers for the study. Primary data were collected with the aid of structured questionnaire administered to the respondents. Methods of analysis used include descriptive statistics and Cobb-Douglas stochastic frontier production function model. The results shows that significant variables in the factors of production of food crop in the area were farm size $p \geq 0.01$, labour supply $p \geq 0.01$ and capital input was significant at $p \geq 0.05$ respectively. The determinant variables among inefficiency factors were gender $p \geq 0.05$, herbicides usage $p \geq 0.05$, sole cropping $p \geq 0.05$, and arable crops production, wages and salary means of livelihood (Ws) $p \geq 0.10$. The studies recommend that, Agricultural biotechnology should be encouraged among the rural farmers to bring about improvement in their general food security and their sustainability livelihood.
***Keywords**: Livelihoods, sustainability, food crop, farmers, biotechnology*

INTRODUCTION
Most of the small scale farm holders over a long period of time have device additional means of meeting up with their needs through carrying out different activities on the farm and off farms to generate more income in addition to their farming livelihood. Livelihoods of individuals have become a deliberate strategy to cope with recent time's life challenges (Samuel *et al.*, 2021).

Diversification of farm and off-farm livelihoods among farmers could relief stress on productive agricultural sectors and decrease degradation as well as increase both economic and environmental efficiency (Anyshchenko, 2019). Furthermore, additional income generated from livelihood diversification enable farmers to invest in sustainability measures to manage land degradation as a measure against economic and environmental inefficiencies. Efficiency in production is improved when additional income generated from livelihood diversification is invested into sustainable land management practices that allow food crop producers to attain efficiency in production (Agata *et al.*, 2023).

Biotechnology and the issue of food security, biotechnology is broadly defined as a "technique that uses living organisms or substances from those organisms to make or modify a product, improve plants or animals, or develop microorganisms for specific uses" (Abah *et al.*, 2010). It also deals with the construction of microorganisms, cells, plants or animals with useful traits by recombinant DNA techniques, tissue culture, embryo transfer and other methods besides traditional genetic breeding techniques (Amin *et al.*, 2019). Although, biotechnology applies across a number of fields, agricultural biotechnology however, appears to be the most crucial for African countries and especially for resource-poor farmers whose sole livelihood depends on agriculture (Abdallah *et al.,* 2015). The technique of biotechnology alone cannot solve all the problems associated with agricultural production but it has the potential to address specific problems such as increasing crop productivity, diversifying crops, enhancing nutritional value of food, and also reducing environmental impacts of agricultural production and promoting market competitiveness (Artem, 2022)..

METHODOLOGY

Sampling Procedure and Sample Size: The respondents for this research were chosen using a multi-stage sampling method. At first stage random selection of 33.3% of respondents from Local Government Areas in Zones I, II, and III. Zone I (South) which comprises of Lafia, Doma, Keana, Awe, Obi LGA, while Zone II (North) which comprises of Akwanga, Nasarawa Eggon, Wamba, Kokona and Zone III (West) which comprises of Keffi, Karu, Nasarawa, and Toto using proportionate Allocation Technique which is shown in equation (1). A total of Six LGAs in Nasarawa State were randomly chosen in stage two, one Extension Block was chosen from each of the selected LGAs which gave a total of six Extension Blocks. To arrive at 12 Extension Cells, the final stage involved selecting two Extension Cells at random from each Extension Block which later result to 33.3% of the Cells in each selected Extension Block.

S_h =

Where: S_h =Number of household heads selected,

n= Total number of household heads for the survey, Nh= Farming households in each selected Sub-Cells, and NT= Sum of the farming households in the selected sub-Cells

Method of Data Collection: Questionnaire was used to collect primary data from all the respondents in the selected agricultural zones in, Nasarawa State. The farm families in the research areas served as the sample unit. Data on livelihood/income strategies, household characteristics such as family composition, education, asset ownership, sources of income, agricultural and livestock product sales, buying and selling livelihood involvement, membership in farmer‘s associations and extension contacts. The output of farmers was measured using scale.

Land tenure, cropping patterns, and agricultural output in (Tons) were among the data gathered at the parcel/plot levels. The utilization of labour supply in man-days and other agricultural production inputs was included in the data that was collected.

Analytical Tools:

Descriptive statistics such as frequency distribution, percentage, mean and Cobb-Douglas stochastic frontier production function were used to analyze the generated data for this study. Because of its potential to provide a higher goodness of fit, the Cobb-Douglas stochastic production function was employed to estimate technical efficiency. Individuals' choices of sustainable land management techniques are influenced by household assets, institutional variables, percentage level characteristics, and livelihood strategies.

The model is as follows:

LnY = ∑ ……………… equ (2)

Y= value of total farm output,

Xs= explanatory variables,

X_1= Farm size (ha),

X_2=Total labour (family and hired labour) (mandays),

X_3= Planting materials (seed) (kg), (Measured from grain equivalent table using biotechnology materials),

X_4= Chemical Fertilizer (kg),

X_5 = Organic Fertilizer (kg)

X_6=Agrochemicals (Liters), and

X_7= Capital input (these include depreciation on fixed cost items such as hoes, cutlasses, wheel barrows, hand trowels e.t.c interest payment on borrowed capital, rent payment plan). This was achieved by using the straight line method given as depreciation and captured in naira.

RESULTS AND DISCUSSION

The results on production factors of food crop producers are shown in Table: 1. Coefficients of explanatory variables showed that the coefficient for farm size was significant at 0.01% level. This implies that if farm size is increased by 1% holding other factors of production constant, it will result in additional output of 0.1391%. This is due to the fact that larger farm size will likely result into more output realized by the farmer (if other factors such as agrochemical, viable seed, fertilizer and agronomic management among others are met). Labour supply inputs are also significant at 0.01% level.

Table 1: Production factors of food crop producers

Production Factors	Coefficient	t - ratio
Constant	3.8027	30.1544***
Farm size (ha)	0.1391	4.3258***
Planting materials (seed)/kg	-0.0278	-1.0563
Total labour/mandays (family & hired)	0.1870	5.7286***
Fertilizer	0.0084	0.9808
Capital input (include depreciation fixed cost)	0.0096	0.5013**
Agrochemical	-0.0508	-2680

Source: Field survey, 2022

Table: 2 shows the inefficiency factors of food crop production which are in control of farmers. The result shows that the estimated sigma squared is 0.5293 and significant at 0.01% probability level. This indicates good fit and correctness of specified distributional assumptions of the composite error term. The finding agrees with report of (Amin *et al.*, 2019) who reported similar result of 0.01% level of significance. Results further showed that gamma is estimated to be high with 76.2%. This suggests systematic influence that was not explained by the production function and dominant sources of random errors. Coefficients of inefficiency factors as shown in the Table: 2 were significant for gender (Z_3) which was 5. Herbicides usage (Z_4) was significant at 5%, mono/sole cropping (Z_5) was significant at 5% and LS (Z_7) i.e livelihood strategy two (LS_7) was significant at 10%. The implication for the result of gender is that, more use of male farmers will reduce the level of inefficiency as males possess the required man energy to carryout farming activities than females. This agrees with report of (Artem, 2022) that male farmers are more fit for labour demand in farming than female farmers. Herbicide usage which was significant at 5% shows that the more the use of herbicides, the likely less the inefficiency because herbicides help farmers to cultivate more hectares of land within short period of time and larger farms mostly results in more output as well as more level of efficiency than small farm size (Omena *et al.*, 2011). Negative significance for coefficient of mono/sole cropping is that the more the practice of mono/sole cropping, the more the inefficiency. At this level, mono/sole cropping is discouraged. This agrees with report of Samuel, (2021) who reported that mono cropping is among practices adapted by farmers in specific locations and caused by condition of soil. Coefficient of (LS_7) which is staple crops, wages and salaries was significant but negatively signed. This implies that more of livelihood strategy two will reduce the level of inefficiency that was experience as a result, staple crops production, wages and salary livelihood strategy should be undertaken more among small holder food crop farmers in the study location to reduce inefficiency in production. The result agrees with research of Abah *et al.*, (2010) who reported that livelihood diversification among staple crop producers reduce the level of inefficiency in production.

Table 2: Inefficiency factors of food crop producers

Production Factors	**Parameters**	**Coefficient**	**t - ratio**
Household size	Z_1	-0.5027	-0.1944
Age	Z_2	-0. 0191	0.3281
Gender	Z_3	-0.0278	-1.0563**
Herbicides usage	Z_4	-0.1560	-1.7556**
Sole cropping	Z_5	0.0084	0.8089**
Arable crops production	Z_6	0.0096	0.5013*
Wages and salary	Z_7	-0.0508	1.0680*

Source: Field survey, 2022

RECOMMENDATION

- ✓ It is therefore recommended that more livelihood means and sustainability practices related to biotechnology should be undertaken among smallholder farmers in Nasarawa State.
- ✓ Also, more resource inputs should be used to reduce inefficiency in arable food crop production.
- ✓ Agricultural biotechnology should be encouraged among the rural farmers to bring about improvement in their general food security and their sustainability livelihood.

CONCLUSION

The study revealed that the significant factors of production included in the production function were farm size and labour significant at P≥0.01 respectively, while capital input was significant at P≥0.05. The inefficiency factors of food crop producers that were significant are gender, herbicides usage and mono-cropping significant at P≥0.05 respectively, while the arable crops production, wages and salaries means of livelihood in respect to biotechnology practice was significant at P≥0.10, this was corroborated with (Omena *et al*., 2011). Resource usage among the respondents was 0.50% which shows that they were inefficient in production.

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ASSESSMENT OF EFFECTS OF HYDROTHERMAL TREATMENTS ON THE MINERAL ELEMENT BIOAVAILABILITY OF DRY COCOA BEANS

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ABSTRACT
The study was conducted to assess the effects of hydrothermal treatments on the mineral element bioavailability of dry cocoa beans. Three dry samples of cocoa were used as raw, blanched in water at 50°C and boiled in water at 100°C respectively, dried and ground into powder. Standard methods of analysis were used to determine the parameters and results evaluated. The results showed the following mineral bioavailabilities: [Saponin/Zn^{2+}], (0.140 for raw and 0.170 for 50ºC and 0.150 for 100ºC), for Zn^{2+}, had the highest calculated mole ratio; followed by [Saponin/Fe^{2+}], (0.140 for raw and 0.170 for 50ºC and 0.150 for 100ºC) for Fe^{2+}; [Oxalate/Ca^{2+}], (0.003 for each of the three samples), for Ca^{2+}; [Saponin/Ca^{2+}], (0.004 for raw and 0.005 for both 50ºC and 100ºC), for Ca^{2+} and [Oxalate/Ca^{2+} + Mg^{2+}], (0.000 for raw and 0.001 for both 50ºC and 100ºC) for Ca^{2+} + Mg^{2+} bioavailabilities. The results indicated that there were difference in mineral bioavailabilities based on their ratios. This showed that the bioavailability of minerals was influenced by hydrothermal treatments and indicated that blanching cocoa beans at a temperature of 50ºC is the best method among the methods considered in this work to get better mineral element bioavailability as far as nutrient qualities of cocoa beans are concerned.

INTRODUCTION
Food processing means operations used on raw materials obtained from plants or animals into various food or food ingredients. According to Johnston *et al*. (2014), "Food processing is required to increase shelf life of foods, enhance bioavailability of some nutrients and quality and reduce the post harvest losses and waste''. Burlingame and Dernini (2012); Africa and Asia (2015), stated that, "Reduction in the incidence of food insecurity in present scenario as well as in future require technological approach through collaborative actions among the field of agriculture, food, nutrition and health for improvement of wellness of society''. Kushwaha *et al.* (2021) identified some of the methods that can be used to process food to include traditional processing, heat treatment, low temperature/freezing, drying/dehydration, salting/brining, pickling, curing, fermentation, food additives, thermal processing, among others and they further stated that, "processing causes changes to the components of food and some of these changes can result in both detrimental as well as beneficial effects on the food quality, depending on the process used''. Some of the benefits of food processing include destruction of food-borne microbes and toxins, improved bioavailability of nutrients, extension of shelf-life, improved sensory characteristics and functional properties (van Boekel *et al*., 2010).

Cocoa beans are an important agricultural commodity and also a key raw material in cocoa beverage powder and chocolate production. Numerous studies have been reported on the health benefits of cocoa beans. Wollgast and Anklam (2000), stated that "the polyphenol compounds present in cocoa beans could significantly contribute to their health-promoting activities''. Polyphenols in cocoa had gained much attention recently due to their antioxidant activity and health benefits in the prevention and treatment of cancer (free-radical scavenging activities), cardiovascular diseases and other pathologies (Misnawi and Sulistyowati, 2008).

Studies on cocoa and their related products have become an area of interest owing to their health-promoting properties. Cocoa beans are usually consumed raw or roasted as seeds or in powder form. The aim of the study was to evaluate the mineral element composition, anti-nutritional factor contents and mineral element bioavailability of cocoa beans hydrothermally treated at different temperatures of 50ºC and 100ºC compare the results obtained with those of raw beans (control/standard).

MATERIALS AND METHODS

Area of the study: The experiment was carried out at the Department of Science Laboratory Technology and the Research Laboratory, Oyo State College of Agriculture and Technology. Igboora is in derived savannah zone of 7°15' North and 3°30' East of the equator with an average rainfall of 1278mm and an annual temperature of 27°C (Akamigbo, 2010).

Sample and sample preparation: Ripe mature cocoa pods were obtained from a cocoa farmer in Oyo town, Oyo State, Nigeria. The pods were broken, the beans were scooped out of and and allowed to ferment for six days using the basket fermentation technique. The fermented cocoa beans were sun dried under ambient temperatures (25-32°C) and relative humidity of 85– 100% with stirring four times each day to allow uniform drying of the beans. Cocoa samples were randomly picked at intervals and moisture contents analyzed until moisture content of between 5.5 to 6% was attained. The cocoa beans were immediately packaged in air tight black plastic bags prior to hydrothermal treatments. The cocoa beans were divided into three portions: A portion was left untreated as raw sample, the second portion was blanched at a temperature of 50°C and the third portion was boiled at 100°C.

Determination of some anti-nutritional factor were determined according to the methods described by the methods shown in parenthesis *Tannins* (Joslyn, 1970), *phytate* (Wheeler and Ferrel,1971), *oxalate* (Day and Underwood, 1986).*saponins* (Day and Underwood, 1986) *and hydrogen cyanide contents*(Day and Underwood, 1986).

Determination of some element concentrations: These were determined by the methods of (AOAC, 2012). The minerals were analysed from the solution obtained by first dry ashing the samples at 550°C. The filtered solutions were used to determine Na, K, Ca, Mg, Zn, Fe, Mn, Cu and Co by means of atomic absorption spectrophotometer (Buck Scientific Model -200 A/210, Norwalk, Connecticut 06855) and phosphorus was determined colorimetrically by Spectronic 20 (Gallenkamp, UK) using the phosphovanadomolybdate method.

Calculation/determination of element bioavailability: The bioavailability of elements (calcium, magnesium, iron and zinc) was calculated as reported by Woldegiorgis *et al*. (2015). The molar ratios anti-nutrients (phytates and oxalates) and elements (Ca, Fe and Zn) were obtained by dividing the concentration of anti-nutrient with the concentration of the elements.

Data analysis: The data obtained for the anti-nutrient composition, mineral element contents and mineral bioavailability were statistically analyzed using one way analysis of variance (ANOVA) and reported as mean ± standard error of triplicate data. Duncan's multiple range test was used for mean separation.

RESULTS AND DISCUSSION

Table 1: Anti-nutritional factor (ANF) composition of raw and hydrothermally treated cocoa beans

ANF (mg/100g)	Raw sample	Hydrothermally treated sample	
		50°C	100°C
Tannin	4.614±0.04^{a}	5.115±0.02^{b}	4.927±0.07^{c}
Saponin	14.239±0.01^{a}	16.583±0.17^{b}	16.322±0.02^{b}
Oxalate	0.81±0.02^{a}	0.843±0.05^{a}	0.917±0.02^{c}
Phytate	0.071±1.0^{a}	0.088±0.02^{b}	0.068±0.00^{c}
Hydrogen cyanide	0.004±0.00^{a}	0.006±0.00^{b}	0.002±0.00^{c}

Mean value with different superscript alphabets in each row are significantly different from each other by DMRT (P<0.05)

Table 2: Mineral element composition of raw and hydrothermally treated cocoa beans

Mineral elements (mg/100g)	Raw	Hydrothermally treated	
		50°C	100°C
Sodium	20.166±0.01	19.322±0.01	21.011±0.4
Potassium	1502.387±0.01	1482.515±1.02	1511.701±1.22
Calcium	126.346±0.02	124.184±0.04	128.062±0.88
Magnesium	483.451±0.02	460.775±1.11	489.051±0.11
Phosphorus	728.616±0.02	718.102±0.40	731.066±0.14
Iron	13.118±0.08	12.960±0.01	13.589±0.09
Zinc	6.761±0.02	6.120±0.05	6.824±0.09
Copper	3.834±0.04	3.488±0.08	3.788±0.10
Chromium	1.029±0.02	1.177±0.11	1.098±0.09
Cobalt	1.084±0.03	1.116±0.05	1.162±0.08

Table 3: Mineral elements bioavailability of raw and hydrothermally treated cocoa beans

Antinutrient to mineral element ratio	Calculated mole ratio (element bioavailability)		
	Raw	50ºC	100ºC
[Oxalate]/[Ca]	0.003^{a}	0.003^{a}	0.003^{a}
[Oxalate]/[Ca+Mg]	0.000^{a}	0.001^{b}	0.001^{b}
[Saponin]/[Zn]	0.140^{a}	0.170^{b}	0.150^{a}
[Saponin]/[Ca]	0.004^{a}	0.005^{a}	0.005^{a}
[Saponin]/[Fe]	0.060^{a}	0.069^{b}	0.066^{b}

Mean value with different superscript alphabets in each row are significantly different from each other by DMRT ($P<0.05$)

DISCUSSION

The results of the anti-nutritional factors composition of raw and hydrothermally treated cocoa beans were shown in Table 1. Quantitatively, cocoa beans hydrothermally treated at 50ºC has the highest value of anti-nutritional factors except for oxalate which is relatively lower. Anti-nutritional factors in cocoa beans (tannin, saponin, oxalate, phytate and hydrogen cyanide) found in varying quantities in raw and hydrothermally treated cocoa beans. Anti-nutritional factors are lethal or poisonous when consumed in large quantity, which have negative effects on mineral bioavailability (Ojiako and Igwe, 2008). Anti-nutritional factors reduces the maximum yield of nutrients especially proteins, vitamins and minerals; thereby, inhibiting the optional exploitation of nutrients by reducing the nutrient values. All the anti-nutritional factors determined in this study were observed to be higher in the sample hydrothermally treated at 50°C except for oxalate. This was in agreement with the finding of Ekholm (2003). The results showed that blanched cocoa beans had the highest value of tannins, saponins, phytate and hydrogen cyanide with the value 5.115±0.002, 16.583±0.169, 0.088±0.002 and 0.006±0.000 respectively, except for oxalate, which is relatively, lower which is 0.843±0.005.

The results of the mineral elements composition of raw and hydrothermally treated cocoa beans were shown in Table 2. Quantitatively, cocoa beans hydrothermally treated at 100ºC had the highest values for mineral element compositions except of copper and chromium, which were relatively lower. The highest levels of mineral obtained in this study were in the samples that were hydrothermally treated at 100ºC while the lowest values for minerals untreated and at 50^{0}C. The mineral element contents of the boiled sample gave the highest values (in mg/100g) of elements sodium, potassium, calcium, magnesium and phosphorous which were 21.011±0.4, 1511.701±1.22, 128.062±0.88, 489.051±0.11, 731.066±0.14, 13.589±0.09 respectively while the blanched gave the lowest values of 19.322±0.001, 1482.515±1.02, 124.184±0.04, 460.775±1.11, 718.102±0.40, 12.960±0.01 respectively.

Table 3 showed the mineral elements bioavailability of raw and hydrothermally treated cocoa beans. Quantitatively, [Saponin/Zn^{2+}], (0.140 for raw and 0.170 for 50ºC and 0.150 for 100ºC), for Zn^{2+}, had the highest calculated mole ratio; followed by [Saponin/Fe^{2+}], (0.140 for raw and 0.170 for 50ºC and 0.150 for 100ºC) for Fe^{2+}; [Oxalate/Ca^{2+}], (0.003 for each of the three samples), for Ca^{2+}; [Saponin/Ca^{2+}], (0.004 for raw and 0.005 for both 50ºC and 100ºC), for Ca^{2+} and [Oxalate/Ca^{2+} + Mg^{2+}], (0.000 for raw and 0.001 for both 50ºC and 100ºC) for Ca^{2+} + Mg^{2+} bioavailabilities with the following values**.** The results indicated a significant difference in mineral absorption based on these ratios. This finding suggests that the bioavailability of minerals was influenced by the presence of oxalate, saponnin, and their interactions with calcium, zinc, and iron.

CONCLUSION

The effects of hydrothermal treatments on cocoa beans was investigated, with the raw sample serving as the reference of comparison, in this study, and the focus on their effects on anti-nutritional factor compositions, mineral element contents and mineral element bioavailability. The results revealed that hydrothermal treatment had significant effects on the levels of anti-nutritional factors in cocoa beans. The findings indicated that cocoa beans subjected to hydrothermal treatment at 100ºC led to an increase in mineral element concentrations compared to the raw sample. Conversely, cocoa beans treated at 50ºC showed a reduction in mineral concentration compared to the raw sample. These observations highlight the temperature-dependent influence of hydrothermal treatments on mineral content in cocoa beans. The results indicated there were difference in mineral bioavailabilities based on their ratios. This showed that the bioavailability of minerals was influenced by hydrothermal treatments and indicated that blanching cocoa beans at a temperature of 50ºC is the best method among the methods considered in this work to get better mineral element bioavailability as far as nutrient qualities of cocoa beans are concerned.

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GAMMA DOSE RATE EXPOSURE LEVEL IN A PLANTED WATER LEAF VEGETABLE

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ABSTRACT
Naturally occurring radionuclide's materials are usually absorbed by the plant through root as nutrients for their growth, which can pose a radiation risk to the human being when consumed as food. This study focused on the gamma dose rate exposure levels in a cultivated water leaf vegetable and was carried out in Oyo State College of Agriculture Technology botanical garden. The vegetable was planted and watered for four weeks in a nursery bed and measurement and recording were taken by the use of Gamma Survey Meter for dose rate of radiation emitted by water leafy vegetable of three times per day for two days were taken Data collected were analysed using descriptive tools tabulated and shown with the aid of Bar chart and compared with United Nation Scientific Committee on the effect of Atomic Radiation (UNCEAR) permissible dose rate of 2.7 µSv per year .The results revealed that all the cultivated vegetable samples had low gamma dose rate compare to UNCEAR permissible limit of 2.7 µSv. It can be concluded that Gamma dose rate does not have effect on consumption of the vegetable produced and pose no risk of any cancer related diseases.
Keywords: *Water leaf vegetable, Gamma dose rate, Exposure, Radiation, Survey meter*

INTRODUCTION
Radionuclide are found in all the environmental elements. They are present in varying amounts in the air, water, vegetables, animals, soil, and rocks (Abdulhussein e.al.2016. .Generally, the vegetables may cause an accumulation of radionuclide in their organs, which may additionally rely on the chemical and physical properties of the soil. So, there may be multiplied risk to the human population via food chain Mustakin et.al. 2018. Humans are exposed to both internal and external radiation from these natural sources. Internal exposure occurs through the intake of primordial radionuclide through inhalation or ingestion Changizi et.al, 2010. Ingestion exposure dose mostly results from 238U and 232Th series radionuclide and 40K in drinking water and foodstuff Khan, et al., 2010.For the derivation of several important minerals, dietary fibres and vitamins, humans rely heavily on vegetables .Anas and Yusuf, 2017. And as such, vegetables have become one of the most important source of food supply and nourishments to humans There have been several studies on radionuclide contaminants of common food stuffs in Nigeria, Amakom *et al*., 2018 investigated the gross alpha and beta activity concentrations in cassava and fluted pumpkin; Arogunjo *et a*l., 2005 determined the radionuclide concentrations from major cereals and tubers consumed in Nige ria. Sometimes, man-made radionuclides contaminate the food chain as a result of fallout from nuclear weapons tests in the atmosphere or from routine and accidental release of nuclear wastes as reported by IAEA 1989. As the spatial distribution of radionuclide varies with respect to the parent soils from region to region Keser *et.al*.,2013, so also, their uptake by plants varies from place to place o also their uptake by plants varies from place to place even among similar cultivars (Pendo and Leonid, 2017).

MATERIALS
Water leaf seed
Cutlass
Hoe
Gamma survey meter

METHODS

Area of Study

The experiment was carried out at Botanical garden, Oyo State College of Agriculture and Technology Igboora. (OYSCATECH)

Sample collection

The viable seed of water leaf was bought from Towobowo market in Igboora, and Nursery bed was prepared for the vegetable.

Experimental procedure

Some portion of the land was cleared and nursery bed made by the use of cutlass and hoe, thereafter the seed of water leaf vegetable was planted at the OYSCATECH Botanical garden. The water (Green leaf) was watered for four (4) weeks before the measurements were taken, the gamma survey meter was used to measure the dose rate in the morning, afternoon and the evening for two days. The measurement and recording were taken with the use of gamma survey meter in Micro sievert. (μSv).

RESULTS AND DISCUSSION

TABLE 1: Gamma dose rate of reading

Table 1 Gamma dose rate of reading in day 1 from planted water leaf vegetable

Day1	Readings μSv					Range	Average
Vegetable	1	2	3	4	5	Min –Max	
Morning	0.026	0.035	0.026	0.025	0.027	0.025-0.035	0.0278
Afternoon	0.024	0.022	0.023	0.025	0.026	0.022-0.026	0.024
Evening	0.021	0.031	0.028	0.020	0.022	0.020-0.031	0.0244

TABLE 2: Gamma dose rate of reading

Table 2 Gamma dose rate of reading in day 2 from planted water leaf vegetable .

Day2	Readings μSv					Range	Average
Vegetable	1	2	3	4	5	Min –Max	
Morning	0.021	0.025	0.017	0.019	0.025	0.017-0.025	0.0214
Afternoon	0.025	0.026	0.024	0.027	0.028	0.024-0.028	0.026
Evening	0.024	0.032	0.023	0.033	0.035	0.023-0.033	0.0274

The table 1 showed above the result of gamma dose rate readings taken and recorded three times from the five samples in a day (morning, afternoon and evening).The result indicated that morning had the highest average value of 0.0278μSv, evening had the average value of 0.0244μSv and afternoon had the lowest average value of 0.024μSv.

The day 2 table showed the results of gamma dose rate of readings taken and recorded three times from five samples (morning, afternoon and evening).The result indicated that Evening has the highest average value of r 0.0274μSv, Morning had the average value of 0.0214μSv and afternoon produced the lowest average value of 0.026μSv. .It can be deduced that gamma dose rate emitted from sampled green leaf vegetable from botanical garden from the reading for the average values from day 1 and day 2 ,the highest average values were compared to the international recommended value by United Nation Scientific Committee on the effect of Atomic Radiation (UNCEAR) have the gamma dose rate within the acceptable and permissible dose rate of radiation. The result is not in line with the finding of Jemila et.al.,2022 which stated that The excess lifetime of cancer risk for some vegetable samples was higher than internationally accepted values. But in line with Amakom *et,al*,.2022 that the absorbent dose rate of sampled vegetable were lower than the permissible values indicating consumption safety for those who do not rely heavily on the consumption of these common vegetables

CONCLUSION

The research carried out based on measurement of gamma dose rate emitted from planted vegetable. It can be deduced that all the green leaf vegetable had low gamma dose rate in the day1and day 2, and are not harmful to the body. The activity of concentration shown by gamma absorbed dose rate from indicated that these vegetable had a level of consumption safety when compared with the world permissible values by UNCEAR

It could be concluded that the these gamma dose rate on leaf vegetable from the sample area would not have effect on consumption on human body and does not pose the risk to any cancer related diseases.

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ISOLATION, CHARACTERIZATION AND IDENTIFICATION OF MICROORGANISMS FROM HERBAL MIXTURE SOLD IN OBANTOKO, OGUN STATE, NIGERIA.

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ABSTRACT
Natural combination and blend of plants, roots and barks are depicted as the full scale blend of medicinal herbs and practices used in hindering or taking out physical, mental or social diseases. Standard methods of analysis were used to isolate, identify, characterise and determine both proximate and phytochemical composition of herbal mixtures sold in selected locations in Abeokuta, Ogun State. The results of this present study revealed that the higher coliform count was recorded at E_2 at (464 cfu/g) while the lowest count at (B_1 and D_2) at (03 cfu/g). The highest aerobic count was at C_2 (148 cfu/g) while the lowest count occurred at B_2 (11 cfu/g). The highest fungi load observed at A_1 (4.0 cfu/g) while the lowest at B_2 (1.0 cfu/g). The probable organisms isolated respectively from this study were Staphylococcus, Streptococcus species and Moraxella species. Manufacturers should ensure the highest possible level of hygiene during manufacturing in order to ensure safety of the products so as to maintain correct quality, safety and efficacy of the final herbal preparations.

INTRODUCTION
The utilization of home grown medication has forever been essential for human culture, as certain plants have significant helpful properties, which can be utilized to fix human and other creature illnesses. The utilization of these home grown cures have expanded essentially in the last a few decades in Nigeria. This has prompted the creation of natural items with counterfeit cases that it can fix all types of infirmities (Oyetayo, 2008).
In this way, the quality and wellbeing of natural arrangements are of extraordinary concern since quality is the premise of reproducible adequacy and security of home grown drugs, and to guarantee the norm of exploration on home grown medications, the nature of the plant materials or arrangements is of most extreme significance and must thusly be examined (Sara, 2023).
Microbial examination is a term that alludes to the recognition of microorganism in a given example or item to discover its sterile state. No matter what the type of natural readiness, some microbial investigation is imperative. The point of this study was to lay out the microbial nature of home grown arrangements got from sellers in Obantoko, South Western part of Nigeria (Joan and Susan, 2021).
Most herbal mixtures do not undergo adequate microbial analysis for effective standardization and good quality control, hence they consist of many pathogens which may consequently damage many important organs in the body such as kidney and liver (Amruta Balekundri and Vinodhkumar Mannur, 2020). It is therefore very important to carry out effective microbial examination in order to be able to isolate, identify and know the characteristics of any micro-organisms present in the herbal mixture for effective control measures.
The Aim of the Study is to isolate, identify and characterize microorganisms present in herbal mixtures sold in selected locations of Ogun State metropolis.

MATERIALS AND METHOD
The study was carried out in the Food Microbiology Laboratory, Food Science and Technology Department, COLFHEC, Federal University of Agriculture, Abeokuta.
Ten different samples of locally prepared herbal mixtures were bought from five different locations in Obantoko, Ogun State metropolis and were designated as A-E.
The herbal mixtures were collected in sterile containers for laboratory analysis.

Isolation of Bacteria and Fungi Cultures in herbal mixtures Sample

Five-fold serial dilutions of samples of the herbal mixtures were prepared 1ml of appropriate dilution (1,2,3) was inoculated into MacConkey Agar and Nutrient Agar using pour plate technique respectively. The inoculated plates were then incubated at 37^0C in an inverted position in the incubator for 24hours. The culture plates were then examined for colony growth and observations were recorded (AOAC, 2006; Hunter and Barnnet, 2012).

Five-fold serial dilutions of samples of the herbal mixtures were prepared and 1ml appropriate dilution (1,2,3) was inoculated into Potato Dextrose Agar (PDA) using pour plate technique. The inoculated plates were then incubated at 25^0C for 72hours for fungi growth and observations were recorded. The fungi and bacteria that grow on the media were identified using standardized procedures (Barnett and Hunter, 2012).

Colonies that appear on the surface of the agar plates were counted and recorded. The coliform colony forming units of each herbal mixture sample was calculated using:

$$Colony\ forming\ units\ = \frac{number\ of\ colomies}{volume\ of\ sample\ inoculated * dilition\ factor}$$

Pure cultures were obtained by sub-culturing from mixed culture plates using streak method (AOAC, 2006).

Characterization of Bacterial and fungi Isolates from herbal mixture samples

Pure aerobic bacterial isolates were characterized using cultural, morphological and biochemical characteristics of isolates in different nutrient media preparations. Pure culture was obtained by sub-culturing using streaking method. The morphological characteristics observed were, shape (circular, irregular, spreading), elevation (flat, slightly raised or markedly raised), pigmentation (red, white, pink, colorless), size (pinpoint, small, medium, large) and texture. Microscopy of the isolates was done and observed for arrangement, gram stain reaction and shape. Biochemical tests such as catalase test, oxidase test, indole test, citrate test and methyl red-Vogas Proskauer test were carried out \zaccording to the procedure described by Tokuyasu *et al.* (2012).

Identification of isolates

Bacterial and fungi isolates characterized above were identified by comparing with Bergey's manual of determinative bacteriology (Bergey, 1994; Hunter and Barnnet, 2012)

Data analysis

The data on bacterial and fungal isolates and characterization were analysed by One Way of Analysis Variance (ANOVA) using SPSS 16.0 version and the percentage of bacteria and fungi occurrence were separated.

RESULTS AND DISCUSSION

Table 1: Colonies Count of Bacterial on Nutrient Agar for Herbal Mixture Samples

Sample Codes	$Na10^3$	$Na10^4$	$Na10^5$	N_a (Control)
A_1	19	05	02	
A_2	20	No growth	No growth	______
B_1	46	10	01	
B_2	11	04	01	______
C_1	36	No growth	No growth	
C_2	148	145	No growth	______
D_1	06	03	No growth	
D_2	19	17	01	______
E_1	138	136	01	
E_2	140	128	35	______

Key words:A1, B1, C1, D1 and E1 represent herbal mixture for gonorrhea treatment.
A2, B2, C2, D2 and E2 represent herbal mixture for syphilis treatment.

A1 shown that there is lesser growth of bacteria while there is more growth of bacterial in C^2 which can be harmful to human, which may be because of the water or the environment in which the herbal is being prepared or the way it being prepared.

Table 2: Colonies Count of Bacterial on MacConkey agar for Herbal Mixture Samples

Sample	$Mac10^3$	$Mac10^4$	$Mac10^5$
A_1	-	-	-
A_2	-	-	-
B_1	03	01	-
B_2	11	04	01
C_1	250	180	-
C_2	305	300	208
D_1	20	02	03
D_2	03	01	-
E_1	136	16	-
E_2	464	450	248

Key words:A1, B1, C1, D1 and E1 represent herbal mixture for gonorrhea treatment.
A2, B2, C2, D2 and E2 represent herbal mixture for syphilis treatment.

Table 3: Morphological identification of Fungi on herbal mixture samples

Sample	Dilution $\mathbf{10^1}$	Dilution $\mathbf{10^2}$	Dilution $\mathbf{10^3}$
	Description	**Description**	**Description**
A_1	Mold, pink at the middle, white edge, green, cream (yeast)	Mold (white fluffy) Mold (Black with spores, white edges)	Mold (white on surface, black at reverse, a bit fluffy) Yeast (mucoid, cream)
A_2	Green (mold), cream (yeast), cream (mold)	Mold (white on surface, cream at reverse)	Mold (white on surface, cream at reverse)
B_1	Mold, pink at the middle, white edge, fluffy, yeast (cream, circular)	Mold (white, fluffy, pink at the middle) Mold (white, black at the middle)	Mold (white, fluffy, pink at the middle)
B_2	Mold (green with spores), yeast (cream)	Mold (cream)	Mold (white, fluffy, pink at the middle) Mold (cream)
C_1	Yeast cream, circular) Mold (Green) Mold (fluffy, white) Mold (white, green at middle, fluffy)	Mold (cream) Yeast (cream, mucoid)	Mold (white, fluffy)
C_2	Black with spores Yeast cream Mold green	Mold (Green) Mold (black with spores) Yeast (cream, mucoid)	Yeast (cream, mucoid) Mold (Green) Mold (white, pink at reverse)
D_1	Mold (Black with spores, white edges) Mold (grey, black at reverse)	Yeast (cream, mucoid) Mold (white on surface, black at reverse)	Yeast (cream, mucoid) Mold (white on surface, black at reverse)
D_2	Mold (Green) Mold (white, black at the reverse, fluffy) Mold (white, black at reverse)	Mold (black with spore, white edges)	
E_1	Mold (black) with spores	Mold (white) Yeast (cream, mucoid)	Yeast (mucoid, cream)
E_2	Mold (black) with spores	Mold (white) Mold (black with spores)	Mold (white) Yeast (cream)

This study aimed at isolation, characterization and identification of microorganisms from herbal mixture sold in obantoko, Ogun State, Nigeria. The results of the present study revealed that there was a remarkable bacterial and fungal contamination of the different herbal infusions sampled. The samples were contaminated to varying degrees with pathogenic bacteria and fungi. All the herbal mixture samples was however has bacterial contamination, while all the samples also showed fungal contaminants. The fungal counts ranged from 0 cfu/mL to 450×108cfu/mL and the fungal counts ranged from 3.0×106cfu/mL to 3.5×108cfu/mL. These results differ from the work of Abba et al. (2009) who reported average bacterial counts that ranged between 1.0 x 107cfu/g and 1.8 x 108cfu/g in powdered herbal preparations sold in Kaduna metropolis. The high counts of bacteria detected in the herbal infusion in this present study may be due to poor hygiene, use of contaminated water for washing and preparation, use of contaminated equipment and contaminated packaging materials. Other possible sources of contaminants are the personnel that could introduce the microbes when handling the raw materials during processing. "The presence of microbial contaminants in non sterile pharmaceutical products can reduce or even inactivate the therapeutic activity of the products and has the potential to adversely affect patient taking the medicine" This facts was supported by the article review on "rapid monitoring of microbial contamination "by

Nakayima et al., (2005), Okunlola et al., (2007). The possible contaminated organisms were isolated from these product, are staph, Salerocorcus species and Moraae Moraxella. And the organisms isolated are the same with other finding results from other researchers that work on isolating microorganisms from herbal mistures. And this organisms may have occur, maybe a result of inadequate heat processing, improper handling of products and contamination processing equipment and supported by the work of (Frazier and Westhoff, 2003).

CONCLUSION AND RECOMMENDATION

The whole herbal medicine showed significant microbial growth all the herbal medicine bought from these locations. This could be due to bad manufacturing process and also raw materials used, for this production may have not been properly sterilize, which might lead to increase in the microbial content, and poor handing in preparing and packaging this herbal product. There is need for constant monitoring and quality control of herbal medicinal products sold in Obantoko Metropolis Ogun State.

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EVALUATION OF ALIAGRA LIQUID ORGANIC FERTILIZER ON GROWTH AND HERBAGE YIELD OF OKRA (*ABELMOSCHUS ESCULENTUS* L. MOENCH) IN LAFIA AND AKWANGA LGA OF NASARAWA STATE

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ABSTRACT
The experiment was conducted during dry season of 2021 cropping season at the Teaching and Research Farm of the Faculty of Agriculture, Nasarawa State University Keffi, Shabu-Lafia Campus and Akwanga LGA of Nasarawa State. The experiment was laid out in a Randomized Complete Block Design (RCBD) and replicated three times with the treatments as: 40 L/ha hydrate + 1L/2ha propagate stages 1-4,40 L/ha hydrate + 1L/2ha propagate stages 1+2, 40 L/ha hydrate + 1L/2ha propagate stages 3+4, 1 L/2ha propagate stage 1-4, 1L/2ha propagate stage 1+2, 1L/2ha propagate stage 3+4, 4 tons/ha poultry manure 150 kg N.P.K fertilizer and T9= control. Data were collected on plant height, number of leaves, leaves area, stem girth and herbage weight. The result revealed significant (P<0.05) different in the plant height. Application of 40L/ha hydrate+1L/2ha propagate stage 1-4 produced significantly taller plant at 3-5 Weeks After Sowing (WAS) in both Lafia and Akwanga LGA, and at 7 WAS poultry manure produced significantly significant taller plants in both locations. 40L/ha hydrate+1L/2ha propagate stage 1-4 and 4t/ha poultry manure produced statistically the same higher number of leaves at all stage of growth. Poultry manure produced largest leaves area at 3-7 WAS. Application of 40L/ha hydrate+1L/2a ha hydrate stage 1-4 and 4t/ha poultry manure recorded statistically the same biggest stem girth in both locations at all stage of growth. The application of 40L/ha hydrate+1L/2ha propagate stage 1-4 produced significant heavier herbage yield in both locations compared to control.. Based on the result obtained in this study, I will recommend that for good growth and herbage weight of okra application of 40L/ha hydrate+1L/2ha propagate stage 1-4 should be used.
Keywords: *Aliagra, hydrate, propagate, liquid, fertilizer, okra*

INTRODUCTION
Okra (*Abelmoschus esculentus* L. Moench) production has been known to be one of the most important vegetable productions in Nigeria. It is an annual crop which can be grown all year round across Nigeria and it is grown mainly as fruit and leaf, vegetable in both green and dried form, for both human and animal consumption. The crop is planted all year round in both tropical forest zone and humid (Adewole *et al.,* 2012). Okra production in Nigeria is predominantly carried out by the resource poor farmers. According to Awodoyin and Oluseum (2009), the immature fruits and leaves of okra are used in the soup as a thickener because it is a rich source of vitamins and minerals. When cooked, okra can give the following nutrition benefits: Protein, niacin, riboflavin, phosphorus, zinc, copper, potassium, vitamins A, B6, C, and K, thiamine, magnesium, folate, calcium, and manganese (Akanbi *et al.,* 2010). In spite of multiple benefit of okra, because of dependence on the natural soil fertility and labour which is usually very costly and not economically profitable its production is very low in most of developing country (Tiamiyu *et al.*, 2012; Schippers, 2000). Okra yield per hectare in Nigeria is very low and is reported to be at about 2 tons per hectare (FAO, 2007)) compared to other nations where okra crop are been produced, because of low innate soil fertility status among other factors. The increasing demand for okra by the majority of people

for food and domestic purposes in Nigeria in recent time make it necessary to look for way of increasing its yield through liquid organic fertilizer application. Aliagra products (propagate liquid organic fertilizer) is a natural nontoxic liquid formulation. It has four stages management program that promotes outstanding results from planting to harvest, increasing the number of flowers per plant while subsequently increasing fruit yield and delivering the critical biostimulant requirements for overall plant health during the entire growing season. The stages of application slated by the manufacturer are: stage 1, propagate promotes microbial life into tired soils, thereby repairing past damage. Stage 2 propagate is an energy-rich hybrid product to feed the microbial life. Stage 3 propagate promotes induced systemic resistance for plant resilience, promoting heat, drought and disease stress. Stage 4 propagate is a bio-stimulant that extends flowering. Hydrate liquid fertilizer delivers quality turf and plant health by introducing microbes to the soil so that it can hold as much as four-times water while producing enzymes that increase water filtration and absorption. Additionally, these microbes store plant nutrients for slow release feeding, fix nitrogen from the air and solubilizing phosphorus that is trapped in the soil. According to the manufacturer, Aliagra products are derived from calcium nitrate, potassium nitrate, phosphoric acid, and monopotassium phosphate and potassium polysaccharide. Work on the field evaluation of liquid organic fertilizer for adoption into the farming system has been reported by many researchers (Jayasundara *et al.*, 2016; Oluwagbenga and Caleb 2016; Vemaraju, 2014) however, Aliagra liquid organic fertilizers are new products and have not been used in this agro-ecological zone. Therefore, this study seeks to evaluate the efficacy of Aliagra liquid organic fertilizer with poultry manure and N P K fertilizer on the growth and herbage yield of okra.

MATERIALS AND METHODS

Description of the Experimental Sites

The study was carried out in two (2) locations; at the Teaching and Research Farm of the Faculty of Agriculture, Nasarawa State University Keffi, Shabu- Lafia, Campus located on latitude 8^0.33`N and longitude $8^0$.32`E with a mean elevation of 181.53 m above sea level (Jayeoba, 2013), and Akwanga LGA located on Latitude 9^0.176`N and Longitude $8^0$.040`E with a mean altitude of 493 m above sea level. Both areas are located in Nasarawa state, within the Southern Guinea Savanna Zone of North Central Nigeria.

Experimental Design and Treatments

The experiments were laid out in a randomized complete block design (RCBD) consist of nine (9) treatments and replicated three (3) times on 216 m^2 field with plot size of 2 m x 2 m (4 m^2) for each replicate. The treatments were as follow; 40 L/ha hydrate + 1 L/2ha propagate stage 1-4 (complete application), 40L/ha hydrate+ 1 L/2ha propagate stage 1+2, 40 L/ha hydrate+ 1 L/2ha propagate stage 3+4, 1 L/2ha propagate stage 1-4, 1 L/2ha propagate stage 1+ 2, 1 L/2ha propagate stage 3+4, 4 tons/ha poultry manure, 150 kg/ha N P K fertilizer and control (No application).

The experimental area was cleared, tilled and seedbed constructed using manual implement (hoe and cutlass). Poultry manure was incorporated into the seedbed at rate of 4 tons/ha and irrigated with water for two weeks before sowing of okra seed. Three local variety of okra seeds (ladyfinger) was sown per hole at 2 cm depth and at a spacing of 60 cm x 45 cm. Germinated stands were thinned to two plants per stand at 2 WAS. Application of Aliagra Liquid Organic Products, Hydrate liquid organic fertilizer was applied to the soil 1 WAS at a rate of 1litre in 15 litres of water per 250 m^2. Propagate liquid organic fertilizer was applied during different stage of plant growth. stage 1 and 2 were applied to the soil at 1 to 2 WAS and 3 to 4 WAS, respectively at a rate of 1litre in 250 litres of water per two hectares, stage 3 and 4 were applied in the form of foliar application at 5 to 6 WAS (full vegetative growth) and 7 to 8 WAS (at flower initiation) at rate of 1litre in 250 litres of water per two hectares. The NPK fertilizer was applied at rate of 150 kg/ha 1 WAS. Weeding (hoeing) was carried out at 3 and 5 WAS and supplementary hand pulling before the maturity of the okra crops. Data collection was carried out on four randomly tagged plant in each plot, Plant height (cm) was measured from the soil surface to the terminal bud with the aid of meter rule and the mean recorded for each treatment. Number of leaves per plant all fully expanded leaves per plant were counted and the mean recorded for each treatment. Leaf area (cm^2) was determined by measuring the leaf length and width of the tagged plant. The leaf area was estimated by using the equation; leaf area = 0.62 (L x W) (Musa and Hassan, 2016), Stem diameter (cm) was measured using a Vernier caliper. Harvested herbage from each tagged plant in a plot were weighed using an electronic weighing scale and the mean were converted to tons per hectare.

Statistical Analysis

Data collected on growth and herbage yield parameters were compiled and analyzed statistically using GENSTAT software (2008 Ed). Data were subjected to analysis of variance (ANOVA) using the General Linear Model Procedure. Least Significant Difference (LSD) was used to separate the mean for the parameters measured at 5 percent level of probability ($P \leq 0.05$)

RESULTS AND DISCUSSION

Effect of Aliagra liquid organic fertilizer, NKP fertilizer and poultry manure on plant height of Okra

The result of analysis of plant height is presented in table 1. In both Lafia and Akwanga during 2021 cropping season, the result revealed that there was significant ($P<0.05$) different in the plant height of okra. Application of 40L/ha hydrate + 1L/2ha propagate stage 1-4 produced significantly tallest plant in both location at 3 to 5 weeks after sowing (WAS) followed by 4tons/ha poultry manure and shortest plant was recorded in control plot. At 7 WAS plant height were significantly taller at both location with application of 4tons/ha poultry manure compare to control. The tallest plant recorded could be attributed to the ability of Aliagra liquid organic fertilizer (hydrate and propagate) and poultry manure to retain water and supply soil organic nutrient and biostimulants more quickly to okra plant which supported its growth, the taller plant observed indicate that okra was able to utilized nutrient element present in the liquid organic fertilizer. This is in conformity with the finding of Nelson *et a*l, (2010) and is in agreement with the study of Martinez-Alcantara *et al* (2016) who reported that either animals or plant based liquid organic fertilizer produced tallest plant than mineral fertilizer.

Table 1. Effect of Aliagra liquid organic fertilizer, N K P fertilizer and poultry manure on plant height (cm) of Okra

TREATMENTS		Lafia			Akwanga	
	3WAS	5WAS	7WAS	3WAS	5WAS	7WAS
40L/haHydrate+1L/2hapropagate1-4	8.30a	18.83a	25.40b	8.90a	19.57a	27.40b
40L/haHydrate+1L/2hapropagate1-2	6.70cd	15.96c	20.36d	6.86de	16.57cd	22.34d
40L/haHydrate+1L/2ha propagate3-4	6.76c	15.20e	18.23ef	6.80e	16.27d	20.24f
1L/2ha Propagate stag1-4	6.96c	15.26e	18.03f	7.63c	16.34d	21.17e
1L/2ha Propagate stage1-2	6.90c	15.23e	18.36e	6.90de	16.30d	20.34f
1L/2ha Propagate stage3-4	6.86c	15.73d	17.63g	7.16d	15.84e	19.67g
Poultry Manure 4t/ha	7.50b	17.63b	28.66a	8.36b	18.70b	29.40a
N P K 150kg/ha	6.50d	15.70d	22.60c	7.46c	16.80c	23.37c
Control	6.06e	14.07f	16.73h	6.43f	15.24f	17.80h
Mean	6.96	15.84	20.67	7.39	16.85	22.41
SE±	0.068	0.093	0.070	0.102	0.124	0.097
CV%	1.7	0.7	0.6	2.4	1.3	0.8

Means followed with the same letter in a column are not statistically different at 5% level of significance. WAS= week after sowing

Effect of Aliagra liquid organic fertilizer, NPK fertilizer and poultry manure on number of leaves of Okra

Table 2 showed the result of analysis of number of leaves. The result revealed that there was significant ($P<0.05$) different in the number of leaves of okra. At all sampling period (3, 5 and 7) in both locations, 40L/ha hydrate+1L/2ha propagate stage 1-4 and 4tons/ha poultry manure produced statistically highest similar number of leaves compared to other application and the lowest leaves was recorded in control. The increase in leaves production by application of Aliagra liquid organic fertilizer and poultry manure may be attributed to the increase in nutrients uptake in the okra plant leading to improved in cell division and formation hence increased the number of leaves. This is line with the report of Jayansundara *et al*, (2016) and also in agreement with the finding of Abbasi *et al*, (2010) who stated that foliar application of liquid organic fertilizer increased the growth performance of okra plant especially the leaves production.

Effect of Aliagra liquid organic fertilizer, NPK fertilizer and poultry manure on leaves area of Okra.

Table 3 showed the result of leaves area. The result revealed that there was significant ($P<0.05$) different in the leaves area of okra. In both location at all sampling period i.e. from 3,5 and 7 WAS, application of 4tons/ha poultry manure produced significantly widest leaf area compared to other treatment and the smallest leaf was recorded in control. The wider leaf area recorded in poultry manure organic fertilizer indicate that okra plant was able to absorbed and utilized the available nutrients which resulted to wider leaf and attributed to the already soluble nutrients release from poultry manure and was taken up by okra plant resulting to improved cell formation consequently produced widest leaves area. This is similar to the finding of Ramasamy *et al*, (2010) but not in line or agreement with the report of Oluwagbenga *et al* (2016) who state that there was no significant different in the number of leaves using Alpha life liquid bio-fertilizer.

Effect of Aliagra liquid organic fertilizer, NPK fertilizer and poultry manure on the stem girth of okra

Table 4 showed the result of stem girth. The result on the stem girth revealed significant ($P<0.05$) different from 3 to 7 WAS at both locations. Application of 40L/ha hydrate+1L/2ha propagate stage 1-4 and 4tons/ha poultry manure produced statistically similar bigger stem compared to other treatment and smallest stem was recorded in control at all sampling period. The biggest stem recorded in Aliagra liquid organic fertilizer (hydrate+propagate) and poultry manure indicate that liquid organic fertilizer applied in the soil and foliar contain useful and absorbable nutrients needed by okra plant that result in the vigorous growth performance by improved cell formation. therefore, increased the stem girth. This is similar to report of Jayasundara *et al* (2016) when liquid organic fertilizer was compared with poultry manure on growth enhancement of *Abelmoschus esculentus* and *Alternanthera sessilis.r*. and in conformity with the report of thanaporn *et al*, (2019) who stated that liquid organic fertilizer produced after 30 days of fermentation and used at a dilution of 1:100 demonstrated the best growth performance in okra.

Table 2. Effect of Aliagra liquid organic fertilizer, NPK fertilizer and poultry manure on number of leaves of Okra.

TREATMENTS	Lafia			Akwanga		
	3WAS	5WAS	7WAS	3WAS	5WAS	7WAS
40L/haHydrate+1L/2hapropagate1-4	5.07a	8.57a	8.50a	5.06a	8.64a	8.40a
40L/haHydrate+1L/2hapropagate1-2	4.57b	7.50b	7.00bc	4.56b	7.57b	7.00bc
40L/haHydrate+1L/2ha propagate3-4	4.67b	7.14c	6.90c	4.67b	7.20c	6.90bc
1L/2ha Propagate stag1-4	4.50b	7.57b	8.16a	4.50b	7.57b	8.00a
1L/2ha Propagate stage1-2	4.50b	7.40b	7.34b	4.50b	7.40bc	7.34b
1L/2ha Propagate stage3-4	4.50b	7.30bc	7.00bc	4.52b	7.30bc	7.00bc
Poultry Manure 4t/ha	4.90a	8.57a	8.34a	4.90a	8.64a	8.40a
N P K 150kg/ha	4.46b	7.34b	7.24bc	4.47b	7.34bc	7.24b
Control	4.20c	7.06c	6.67c	4.20c	7.07c	6.67c
Mean	4.59	7.60	7.45	4.59	7.64	7.44
SE±	0.070	0.087	0.121	0.070	0.091	0.151
CV%	2.60	2.0	2.80	2.60	2.10	3.50

Means followed with the same letter in a column are not statistically different at 5% level of significance. WAS= week after sowing

Table 3. Effect of Aliagra liquid organic fertilizer, NPK fertilizer and poultry manure on leaf area (cm^2) of Okra

TREATMENT	Lafia			Akwanga		
	3WAS	5WAS	7WAS	3WAS	5WAS	7WAS
40L/haHydrate+1L/2hapropagate1-4	19.14b	117.17b	128.14b	20.07b	118.80b	129.40b
40L/haHydrate+1L/2hapropagate1-2	15.63c	76.10g	79.40h	16.60cd	78.24g	79.90h
40L/haHydrate+1L/2ha propagate3-4	14.40d	76.00g	90.40f	15.50e	76.87h	90.40f
1L/2ha Propagate stag1-4	13.10e	96.80d	97.17d	16.57d	96.80d	97.17d
1L/2ha Propagate stage1-2	13.20e	95.26e	96.04e	15.34e	95.27e	96.04e
1L/2ha Propagate stage3-4	14.47d	85.07f	87.54g	15.34e	85.07f	87.54g
Poultry Manure 4t/ha	21.0a	126.30a	131.24a	21.30a	127.27a	132.17a
N P K 150kg/ha	14.24d	112.14c	116.10c	16.84c	113.24c	116.14c
Control	12.97e	64.10h	72.60i	14.20f	66.34i	74.27i
Mean	15.35	94.32	99.84	16.89	95.31	100.33
SE±	0.077	0.097	0.123	0.083	0.144	0.126
CV%	0.9	0.2	0.2	0.9	0.3	0.2

Means followed with the same letter in a column are not statistically different at 5% level of significance. WAS= week after sowing

Table 4. Effect of Aliagra liquid organic fertilizer, NPK fertilizer and poultry manure on the stem girth (cm) of okra.

TREATMENTS	Lafia			Akwanga		
	3WAS	5WAS	7WAS	3WAS	5WAS	7WAS
40L/haHydrate+1L/2hapropagate1-4	0.37a	0.70ab	0.90a	0.54a	0.87a	0.97a
40L/haHydrate+1L/2hapropagate1-2	0.30ab	0.54c	0.74bc	0.37b	0.67c	0.77b
40L/haHydrate+1L/2ha propagate3-4	0.30ab	0.57bc	0.74bc	0.34b	0.64c	0.74b
1L/2ha Propagate stag1-4	0.30ab	0.64b	0.74bc	0.40b	0.77b	0.74b
1L/2ha Propagate stage1-2	0.27b	0.60bc	0.67c	0.34b	0.67c	0.74b
1L/2ha Propagate stage3-4	0.27b	0.60bc	0.67c	0.34b	0.64c	0.74b
Poultry Manure 4t/ha	0.37a	0.77a	0.97a	0.50a	0.87a	0.97a
N P K 150kg/ha	0.27b	0.64b	0.77b	0.37b	0.67c	0.90a
Control	0.27b	0.57bc	0.64c	0.34b	O.64c	0.70b
Mean	0.30	0.62	0.76	0.39	0.71	0.80
SE±	0.026	0.033	0.028	0.031	0.032	0.034
CV%	6.4	3.6	3.9	13.9	3.1	2.9

Means followed with the same letter in a column are not statistically different at 5% level of significance. WAS= week after sowing

Effect of Aliagra liquid organic fertilizer, NPK fertilizer and poultry manure on herbage yield (Biomass) of okra

Table 5 showed the result of analysis of herbage yield. The result revealed that there was significantly ($P<0.05$) difference in the herbage yield of okra. In Lafia 40L/ha hydrate+1L/2ha propagate stage 1-4 Produced significantly heavier herbage compared to other treatment and, the lowest was recorded in control. At Akwanga 40L/ha hydrate+1L/2ha propagate stage 1-4 and 4t/ha poultry manure produced statistically the same heavier herbage compared to control. The increased in the herbage yield recorded in Aliagra liquid organic fertilizer is as a result of vigorous performance observed in the vegetative growth (plant height, number of leaves, leaves area, stem girth) which indicate that the liquid fertilizer contained essential nutrients needed for the growth and yield of okra. This is in line with Chandrakala (2008) who reported that fresh matter and dry matter yield of chilli were increased with combined application of jeevamruth and panchagavya liquid organic fertilizer.

Table 5. Effect of Aliagra liquid organic fertilizer, NPK fertilizer and poultry manure on herbage yield (Biomass) of okra

TREATMENTS	Lafia	Akwanga
	Weight(t/ha)	Weight(t/ha)
40L/haHydrate+1L/2hapropagate1-4	4.7a	4.8a
40L/haHydrate+1L/2hapropagate1-2	3.5d	3.6c
40L/haHydrate+1L/2ha propagate3-4	3.3e	3.4d
1L/2ha Propagate stag1-4	3.4de	3.4d
1L/2ha Propagate stage1-2	3.3e	3.2e
1L/2ha Propagate stage3-4	3.2ef	3.2
Poultry Manure 4t/ha	4.5b	4.8a
N P K 150kg/ha	3.7c	3.8b
Control	2.9f	3.1f
Mean	3.6	3.7
SE±	0.05	0.03
CV%	1.9	1.5

CONCLUSION AND RECOMMENDATION

Used of fertilizer is essential in crop production especially area low soil fertility to increase growth and yield. In this study the use of Aliagra liquid organic fertilizer improves the availability and mobility of plant nutrients. Thus, increasing the nutrients uptake by okra plant roots leading to vigorous growth. I therefore, recommend that further study should be carry out on other crop with this product to confirm the result.

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INFLUENCE OF ALPHA SPIN NANOPARTICLES AND DIFFERENT ORGANIC MANURE ON THE GERMINATION OF ONION (*ALLIUM CEPA* L.)

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ABSTRACT
An experiment was carried out during the cropping season of 2023 in the Research and Experimental Field of the Botanical Garden of the Department of Plant Science and Biotechnology of Federal University of Lafia, Nasarawa State to investigate the influence of Alpha spin nanoparticles and different Organic manure on the germination of onion (Allium cepa). The onion seeds were exposed to different levels of Alpha pin Nanoparticles at 20min, 40min and 60min alongside the untreated (control). The land was treated with different organic manures which are Cow dung, Poultry droppings and Rice husk alongside untreated plot (control). The experiment was laid out in a 4^2 factorial experiment in Randomized Complete Block Design (RCBD) with three replications. The result revealed that there was a significant difference ($p < 0.05$) in number of days to germinate while there were no significant differences ($P > 0.05$) in the percentage germination and seedling heights. The earliest number of days to germination was recorded under 60minutes of Alpha Spin nanoparticles (N3) and T3 (rice husk) . The highest germination percentage was recorded under 40minutes (N2) with 0.63 and T3 (rice husk) with 0.68. The highest seedling height was recorded under control and T2 (poultry dropping). The result also showed that the alpha spin® nano particles reduced the number of days to germination, increased percentage germination against the control but it reduced the parameter for seedling height. Therefore, it could be concluded that Alpha spin® nanoparticles had little impact on the germination of onion.
Keywords: *Alpha Spin, Nanoparticles, Organic Manure, Germination, Onion*

INTRODUCTION
Onion (*Allium cepa*) is an important worldwide vegetable crop (Best, 2000) which belongs to the family of Liliaceae. It is divised into three groups: *Allium cepa*, *Allium aggregattum, Allium prolilum,* which are all diploids (2n = 2x = 16) (Boukary *et al*., 2012). The crop is a biennial herb of Central Asian origin (Afghanistan, Iran and Pakistan) and is cultivated all around the world. Onion occupies the 4th world rank of consumed vegetables after tomato, cabbage and watermelon with a global annual production of 25 million tonnes) (Boukary *et al*., 2012) *Allium* is the largest and most important representative genus of the Alliaceae family and comprises of 450 species, widely distributed in the northern hemisphere. Besides, the well-known garlic and onion, several species are widely grown for sculinary use, such as leek (*Allium porrum* L.), shallot *(Allium ascalonicum* Hort.) wild garlic (*Allium ursinum* L.), chive (*Allium schoenoprasum* L.) (Marsili, 2017).
The pungency of onions made them popular among poor people throughout the world who could feely use this inexpensive vegetable to spark up their meal. Today China, India, the United State, Russian and Spain are among the leading producers of onions. Onions have a great therapeutic value. They are stimulants and mild counter-irritants. It has been used as a herbal remedy for centuries in colds, coughs, bronchitis and influenza. Onions are well known for their easily assimilable iron content (Gough, 2016). Recent researches establish that the onion has an effective prevention against heart attacks. It is an effective remedy for cholera also. Onions are highly beneficial in the treatment of the disorders of urinary system. Onions are very effective in bleeding piles. Other uses of this herb are teeth disorders, ear disorders, and tuberculosis (Jones, 2010).
The current challenges of sustainability, food security and climate change are engaging researchers in exploring the field of nanotechnology as new source of key improvement for the agricultural sector. Several technological innovation have been employed in agricultural improvement of plants which have resulted in, hybrid variety, synthetic chemicals. Therefore, it will be of immense importance for researchers to seek in nanotechnology a new source of agricultural improvement (Claudio, *et al*., 2015).

Alpha spin optimizes the natural frequency as it can increase harmony in the body by stimulating vital life energy. Any contact with alpha-spin, the molecular structure will create smaller clusters that will make penetration and absorption easy by full optimizing the body's molecular and cellular functions via resonance and then forming a vortex that results in the expression of a quantum energy field which will exert its effect in the content of an organism's body (Gogos *et al.*, 2012). Its functions include improvement of absorption and increase in hydrations, improve micro circulations. It can also be used to facilitate the flow of energy through reflexology frequency, through which it can improve plant growth, seed germination and extend the shelf life of fruits and vegetables (International, 2017).

Nanotechnology has the potential to advance agricultural productivity through genetic improvement of plants, delivery of genes and drug molecules to specific sites at cellular levels, and nano-array based gene-technologies for gene expressions in plants and animals under stress conditions. The potential is increasing with suitable techniques and sensors being identified for precision agriculture, natural resource management, and early detection of pathogens and contaminants. Nanomaterials in agriculture aims in particular to reduce the amount of sprayed chemical products by smart delivery of active ingredients, minimise nutrient losses in fertilisation and increase yields through optimised water and nutrient management (Gogos *et al.*, 2012). The study investigates the effect of Alpha spin nanoparticles and organic manure on the germination of onion.

MATERIALS AND METHODS

This research was carried out in the Botany Garden of Federal University of Lafia, Nasarawa State, located on latitude 8^0 35'N, longitude $8^0$32'E altitude 181.53m above sea level with a mean temperature of 34^0c , relative humidity 0f 40-80 % and average day light of 9-12. It is located in the southern Guinea Savannah Region of North-central Nigeria. In the year 2022. Onion seeds (variety (ies)) were obtained from Nasarawa Agricultural Development Program (NADP).

The treatments comprises of three levels of organic manure (cow dung (T1), poultry drop (T2) and rice husk (T3) and three levels of Alpha Spin nanoparticles at 20min (N1), 30mins (N2) and 60mins (N3) before planting while the untreated seeds were planted alongside the treated seeds and used as control. The experiment was laid out in a 4^2 factorial experiment in a Randomized Complete Block Design (RCBD) with three replications.

Data were collected on the Number of Days to Germination, Number of Germinated Seeds, and Seedling Height (cm).

The data were subjected to Two-Way analysis of variance (ANOVA) using GENSTAT version 17.0 software. Means were separated using least significant difference (LSD) at $p \leq 0.05$.

RESULTS AND DISCUSSION

Number of Days to Germination

The result shows that the differences in the number of days to germination among the plants exposed to alpha spin treatments are significant (Table 1). The number of days to germination of the control and N1 treatment do not significantly differ from each other whereas the N3 treatment was observed to have lowest (6.08) number of days to germination. Also as for the organic manure treatment, the differences in the number of days to germination are significant among the treatments with control having the highest (7.67) while T3 had the lowest (6.33) as indicated in Table 1. What is the implications of this findings / (results presented).

Percentage Germination of Seeds

The effects of the organic manure treatments and alpha spin treatments on the percentage germination are not significant (Table 2). Although the plant exposed to N2 alpha spin treatment had the highest percentage germination (0.63) but not significantly different from that of the control, and other treatments. Similarly, the plants exposed to T3 organic manure treatment was observed to have the highest percentage germination which is not significantly different from the others as indicated in Table 2. You only presented the results but no discussion

Seedling Height

The effects of the organic manure treatments and alpha spin treatments on the seedling height are not significant (Table 3). The control plant had the highest seedling height but not significantly different from those of other alpha spin treatments. Similarly, the plants exposed to T2 organic manure treatment was observed to have the highest seedling height which is not significantly different from the control and others in Table 3. You only presented the results but no discussion.

Table 1: Number of days to germination of plant under Alpha spin and organic manure treatments

Alpha spin Treatments	Organic manure Treatments				Mean
	T0	T1	T2	T3	
N0	9.00	7.67	7.67	6.00	7.58^c
N1	8.00	7.67	7.00	7.00	7.42^c
N2	7.33	6.67	6.67	6.33	6.75^b
N3	6.33	6.00	6.00	6.00	6.08^a

Mean	7.67^{c}	7.00^{b}	6.83^{b}	6.33^{a}
LSD_{OM} = 0.45				

Values with same superscript across same column or same row are not significantly different (P > 0.05)

Table 2: percentage germination of plant under alpha spin and organic manure treatments

Alpha spin Treatments	Organic manure Treatments				**Mean**
	T0	T1	T2	T3	
N0	0.48	0.72	0.52	0.57	0.57^{b}
N1	0.52	0.24	0.54	0.53	0.46^{b}
N2	0.74	0.63	0.61	0.55	0.63^{b}
N3	0.49	0.61	0.45	0.68	0.56^{b}
Mean	0.56^{d}	0.55^{d}	0.53^{d}	0.59^{d}	
	LSD_{OM} = 0.20				

Values with same superscript across same column or same row are not significantly different (P > 0.05)

Table 3: seedling height of plant under alpha spin and organic manure treatments

Alpha spin Treatments	Organic manure Treatments				**Mean**
	T0	T1	T2	T3	
N0	8.43	8.50	11.23	9.30	9.37^{d}
N1	8.63	8.43	8.43	6.73	8.06^{d}
N2	8.67	8.17	8.13	7.93	8.23^{d}
N3	8.20	7.23	6.30	8.77	7.63^{d}
Mean	8.48^{e}	8.08^{e}	8.53^{e}	8.18^{e}	
	LSD_{OM} = 2.12				

Values with same superscript across same column or same row are not significantly different (P > 0.05).

Where:

Alpha Spin®	Organic Manure
N0= Control	T0= Control
N1= 20 Minutes	T1= Cowdung
N2= 40 Minutes	T2= Poultry Dropping
N3= 60 Minutes	T3= Rice Husk

CONCLUSION AND RECOMMENDATIONS

From the findings of this study, it could be concluded that Alpha spin nanoparticles and organic manure have impact on the number of days to germination of onion, percentage germination and seedling height because there were significant differences between the exposed times in the number of days to germinations although there were no significant differences in the percentage germination and seedling heights respectively. Specifically, 60mins (N3) and Rice Husk (T3) treatments reduced the number of days to germination of the plant. This present study recommended that for better seedling height, percentage germination and number of days to germination, onion seeds should be treated with Alpha spin nanoparticles at a longer period of time and organic manure such poultry droppings and rice husk should be used because the lowest number of days to germination, the highest percentage germination and the highest seedling heights were observed in the rice husk and poultry droppings treatments in combination with Alpha spin nanoparticles at 60minutes time of exposure.

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ASSESSMENT OF THE INFLUENCE OF VARIED DEHYDRATION TECHNIQUES ON EPICATECHIN, KAEMPFEROL AND SYRINGIC ACID LEVELS IN GINGER RHIZOMES: A COMPARATIVE ANALYSIS

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ABSTRACT

This study aimed to investigate the impact of different drying methods, namely shade drying, vacuum oven drying, and freeze drying, on the concentration of bioactive compounds, specifically epicatechin, kaempferol, and syringic acid, in ginger (Zingiber officinale). The concentrations of the compounds were measured in milligram per gram (mg/g) in triplicate measurements using high performance liquid chromatography and statistically evaluated for significant differences. For Epicatechin, Vacuum oven drying showed the greatest concentration (0.384± 0.026), followed by freeze drying (0.338± 0.024) and shade drying (0.308± 0.022). Fresh samples, on the other hand, had the lowest Epicatechin content of (0.204± 0.030). Kaempferol concentrations followed a different pattern, with freeze drying producing the greatest concentration (1.201± 0.092), Vacuum oven drying (1.099± 0.065), shade drying (0.926± 0.045), and fresh samples (0.061± 0.053).Furthermore, freeze-dried samples showed the greatest Syringic acid contents (0.221± 0.012), followed by vacuum oven drying (0.191± 0.010), shade drying (0.113± 0.006), and it was not detected in the fresh samples. The results revealed substantial variations in the concentrations of these compounds across the drying methods, shedding light on the optimal preservation method for each of the ginger's bioactive constituents.

INTRODUCTION

Ginger (Zingiber officinale) is widely recognized for its potential health benefits attributed to its diverse array of bioactive compounds, including epicatechin, kaempferol, and syringic acid. These compounds possess antioxidant (Nile and Park, 2015), anti-inflammatory (Zhang et al; 2016), anti-bacterial and potential therapeutic properties (citronberg et al; 2013). Preservation of ginger is crucial to maintaining its nutritional and medicinal value. Various drying methods are employed for this purpose, each potentially influencing the phytochemical profile differently. This study aimed to assess the impact of three common drying methods on the concentration of epicatechin, kaempferol, and syringic acid in ginger.

Experimental

MATERIALS

Methanol
Vacuum oven
Freezer
Whatman filter paper
Rotary vacuum evaporator
Ginger (*Zingiber officinale*)

METHODS

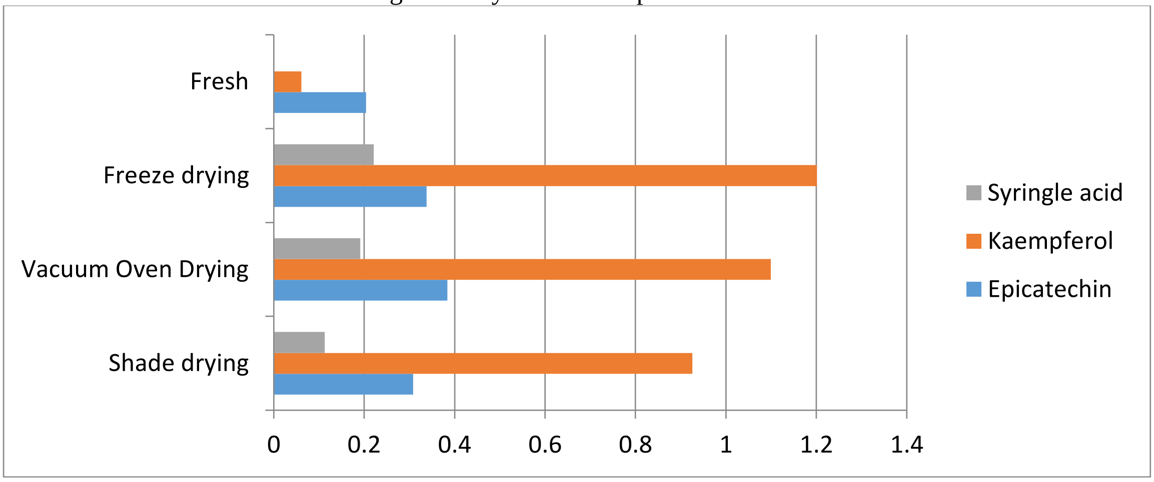
Collection and Preparation of Samples: The sample for this investigation was carefully chosen. For each drying step, the sample was cleaned, weighed, and divided into four equal pieces. Drying methods: Four different drying methods were used: shade drying, freeze drying, vacuum oven drying, and a fresh un-dried control group. Extraction and Analysis of Compounds: Methanol was used as a solvent to extract the dried and fresh ginger samples. 5g weighed and refluxed in a water bath for 15 minutes with methanol (100ml) before filtering using whatman filter paper (No.41). The leftover residue was filtered after being refluxed three times for 15 minutes with 70ml of methanol. The solvent was then evaporated using a rotary vacuum evaporator. This was done on all of the samples. The extract was examined, using high performance liquid chromatography. Statistical Analysis: ANOVA was used to investigate the significance of variations in the means of the various drying procedures.

RESULTS AND DISCUSSION

The results presented in the table below indicated significant variations in the concentrations of Epicatechin, Kaempferol and syringic acid based on the drying method employed.

Drying Method	Epicatechin (mg/g)	Kaempferol (mg/g)	Syringic acid (mg/g)
Shade drying	0.308± 0.022 ^{c}	0.926± 0.045^{c}	0.113± 0.006^{c}
Vacuum Oven drying	0.384± 0.026^{a}	1.099± 0.065^{b}	0.191± 0.010^{b}
Freeze drying	0.338± 0.024 ^{b}	1.201± 0.092^{a}	0.221± 0.012^{a}
Fresh	0.204± 0.030 ^{d}	0.061± 0.053^{d}	ND

The Data represents means of triplicate measurements. The means that are not sharing a common letter in each column for each measurement are significantly different at p<0.05. N D   Not detectable



Among the three compounds studied, kaempferol exhibited the highest sensitivity to drying methods, with freeze drying (1.201 ± 0.092 mg/g) showing the highest concentration (1.099 ± 0.065 mg/g), followed by Vacuum oven drying (1.099 ± 0.065 mg/g), and shade drying (0.926 ± 0.045 mg/g). Epicatechin concentration was highest in vacuum oven dried samples (0.384 ± 0.026 mg/g), while freeze drying resulted in the highest concentration of syringic acid (0.221 ± 0.012 mg/g).

Shade drying exhibited the lowest concentration for all three compounds, likely due to prolonged exposure to light and heat, which can lead to degradation. Vacuum oven drying, characterized by controlled heat and reduced pressure, appeared to be a preferable method for preserving epicatechin. Freeze drying, involving rapid freezing and sublimation, retained higher concentrations of syringic acid and kaempferol.

CONCLUSION

This study highlights the impact of different drying methods on the concentrations of epicatechin, kaempferol, and syringic acid in ginger. The results underscore the need for careful consideration of drying methods when aiming to preserve the bioactive content of ginger. Vacuum-oven drying demonstrated superior preservation of epicatechin, while freeze drying was more effective for syringic acid and kaempferol. These findings provide valuable insights for optimizing the drying process to retain the beneficial bioactive compounds present in ginger.

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MORPHOLOGICAL CHARACTERIZATION OF NIGERIAN TURMERIC LANDRACES

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ABSTRACT

Seven Turmeric landraces were collected from the Genetic Resources Unit of the National Root Crops Research Institute, Umudike, Abia State and characterized in 2022 planting season at Umudike. The seven landraces were laid out in randomized complete block design (RCBD) using three replications. The list of the landracesused were; Ajo (Igbaraodo), Turmeric Uromi, Atale (Yakooyo), kadi – Odo, Atale (Temidire), Red ginger and Ege Apana . Morphological character analysis was based on the "mathematics of information Theory" which allows simultaneous analysis of both quantitative and qualitative data. Principal component analysis have proved to be effective methods in grouping turmeric accession according to their morphological characteristics and better understanding of the existing variability that will facilitate genotypic selection for crop improvement.

Keywords*: Turmeric, Landraces, "mathematics of information Theory, Characterization*

INTRODUCTION

Turmeric (*Curcuma longa* Linn) is a shallow-rooted crop and an herbaceous plant with thick and fleshy rhizomes (Olojede *et al.*, 2009). It is a tropical perennial monocotyledonous herb belonging to the family Zingiberaceae and consists of many species (Jilani *et al*, 2012). Its origin has been traced to south and southern Asia and it has been used in India for at least 2,500 years. *C. longa* Linn is the highest yielding turmeric of commercial value. It is valued for its underground rhizome which contains a yellow coloured phenolic pigment called curcumin which is used as natural colouring agent for food, cosmetics, dye and as an active ingredient in some medicine (Olojede *et al*, 2015). Characterization of germplasm is essential to provide information on the traits of accessions assuring the maximum utilization of the germplasm collection to the final users (Singletary, 2010)). Morphological characterization is an important tool even in the era of molecular characterization because of its reliability and easy identification with less resources for certain stable characters unaltered by environmental interactions. The study was to characterize seven turmeric genotypes for different morphological characters based on Distictiveness, Uniformity and Stability (DUS) guidelines. Therefore, two objectives of this study were to determine the morphological diversity among the seven turmeric landraces and to determine duplication of cultivars within the turmeric landraces.

MATERIALS AND METHODS

The turmeric landraces used for this study were collected from the Genetic Resources Unit of the National Root Crops Research Institute, Umudike, Abia State. The seven landraces were laid out in RCBD using three replications. The list of the genotypes used were; Ajo (Igbaraodo), Turmeric Uromi, Atale (Yakooyo),kadi – Odo , Atale (Temidire),Red ginger and Ege Apana. The plot size was 6m^2 (2m x 3m) using raised beds, while seedling rate was 1 rhizome/stand. The plants were spaced 50cm x 30cm apart between and within rows, respectively. Fertilizer application was at the rate of 400kg per hectare of NPK (15:15:15). First weeding was carried out at between 4 weeks after planting, and roguing was carried out at 10 weeks after planting. Three plants of uniform size and vigor were selected for recording observations.landraceswere evaluated for 19 DUS traits viz., Plant: pseudostem habit, plant height (cm), number of shoots, number of leaves on main stem, Plant leafs: leaf disposition, petiole length (cm), leaf lamina length (cm), leaf lamina width (cm), dorsal leaf colour, ventral leaf colour, leaf venation pattern, leaf margin, vigor. Rhizome: Rhizome habit, rhizome shape, rhizome internode pattern, status of tertiary rhizome, primary rhizome length, number of mother rhizome were recorded at harvest. The assessment of characters was done at 5 months when the plant growth and its morphological characters were optimal. Harvesting was done when the leaves were dried. Morphological character analysis was based on the "mathematics of information Theory" (Nwankwo 2014) which allows simultaneous analysis of both quantitative and qualitative data. Any character or state that is not in alliance with the column characters is discriminatory.

RESULTS AND DISCUSSION

Morphological characters are predominantly used for easy differentiation of genotypes because the characters are expressed genetically involving one or more genes. Among the 7 landraces studied, considerable variation was recorded for all the important characters (Table 1).Based on the mathematics theory that rank all the morphological traits, it was observed (Table 1) that all the seven landraces were related eight out of nineteen characters measured namely: rhizome shape, the same number of leaves on main stem, Plant leaf disposition, petiole length (cm), ventral leaf colour, leaf margin, rhizome internode pattern and primary rhizome length. The eight related characters shows that they are from the same family but distinct and different in eleven traits which indicated they are different and distinct landraces However since none of the landraces are uniform in all the characters ranked showed that there was no duplication of the genotypes Table 1 below

Table 1: Morphological variation among turmeric landraces (Using DUS descriptor)

	Pseudo stem habit	Plant height(cm)	No of shoots	No of leaves on main shoot	Leaf disposition	leaf petiole length(cm)	Lamina length	Lamina width(cm)	Venation pattern	Leaf margin	Leaf color on the ventral side	Leaf color on dorsal side	Vigor
Ajo (Igbaraodo)	9	3	1	5	5	3	3	3	5	5	5	3	1
Turmeric Uromi	9	3	3	5	5	3	5	3	5	5	5	5	1
Atale (Yakooyo)	9	5	3	5	5	3	3	5	5	5	5	3	1
Kadi – Odo	9	3	3	5	5	3	5	5	5	5	5	3	1
Atale (Temidire)	9	3	5	5	5	3	5	3	3	5	5	5	1
Red ginger	9	3	3	5	5	3	3	5	5	5	5	3	1
Ege Apana	9	5	5	7	5	3	3	5	5	5	5	3	1

Note: Each column is a character and the rows respective state or genotype represents status of each genotype for each character

Coded List Of Genotype States.

Explanation of the status of each character expressed by the genotypes

1. Pseudo stem habit: Even= 3, Wavy =5
2. Plant height (cm): Short (<85) = 3, Medium (85-100) = 5
3. Number of shoots: Few (>5) =1, Medium (3-5) =3, Many (>5) = 3
4. Number of leaves on main stem: Intermediate (5-10) = 5, Many (>10) = 7
5. Leaf disposition; Erect (<45°) = 3, Semi-erect (45°-85°) = 5, Horizontal= (>85°) = 7
6. Plant petiole length (cm): Short (<15) = 3, Intermediate (15-25) =5, Long (>25) = 7
7. Leaf lamina length (cm): Short (<30) =3, Medium (30-40) =5, Long (>40) =7
8. Leaf lamina width (cm): Narrow (<10) = 3, Medium (10-15) =5, Broad (>15) =7
9. Leaf colour on dorsal side: Light green =3, Green =5
10. Leaf colour on the ventral side: Dark green= 7, Green =5
11. Leaf venation pattern: Close =3, Distance= 5
12. Vigor: Low vigor= 1, moderately vigorous= 2
13. Leaf margin; Compact = 1, Open = 9
14. .Rhizome habit: Compact= 3, Intermediate=5, Loose= 7
15. Rhizome shape: Straight= 3, Curved=5
16. Rhizome internode pattern: Close (<1) = 3, Distant (>1) =5
17. Status of tertiary rhizome: Absent= 1, Present= 9
18. Primary rhizome length: Short (<5 cm) =3, Medium (5-10 cm) =5, Long (>10 cm) =7
19. Number of mother rhizome: One= 1, Two =3, More than 3=5
20. Internode pattern: Close (<1) = 3, Distance= (>1)

CONCLUSION

Findings show that out of the nineteen descriptor traits used for this experiment, Venation pattern, number of leaves on the main shoot, rhizome habit, lamina length, leaf color on the dorsal side, number of mother rhizome and status of tertiary rhizome are good discriminant descriptor traits for characterizing turmeric landraces. The eight related characters showed that they are from the same family but distinct and different in eleven traits which indicated they are different and distinct landraces However since none of the landraces are uniform in all the characters ranked showed that there was no duplication of the genotypes The variations analyzed using DUS characters offer a bright scope for selection based on desirable morphological traits which can be used in future breeding purposes.

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MORPHOLOGICAL DIVERSITY OF WHITE YAM (*DIOSCOREA ROTUNDATA*) TUBERS FOR BREEDING PURPOSE IN UMUDIKE, SOUTH EAST NIGERIA

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ABSTRACT
Twenty genotypes of Dioscorea rotundata was collected from yam programme of the National Root Crops Research Institute, Umudike, Abia State and was characterized in 2022 planting season at Umudike for enhancing further selection for breeding purpose. The field was marked out into three replications and each replicate was divided in to 20 plots measuring 4m x5m (20m²). The spacing between each replicate was 1m and the spacing between each plot was 0.5m. The sett size was 100g of 20 different genotypes of white yam were the experimental treatments. The experiment was a Randomized Complete Block Design (RCBD) with three replications. Morphological character analysis was based on the "mathematics of information Theory" (Nwankwo 2014) which allows simultaneous analysis of both quantitative and qualitative data have proved to be effective methods in grouping yam genotypes according to their morphological characteristics and better understanding of the existing variability that will facilitate genotypic selection for crop improvement, number of tuber per stand, corm size in relation to tuber size, tuber shape and hairiness of surface are good discriminant descriptor traits for characterizing yam tubers
Keywords: *Morphological Diversity, Genotypes, Mathematics of information Theory*

INTRODUCTION
Yam belongs to the genus Dioscorea in the family Dioscoreacea and is one of the most important staple foods in the world, especially some parts of Tropics and Subtropics (Okigbo and Ogbonnaya, 2006). The edible varieties of yam are important food crops and serve as an important carbohydrate staple for millions of people in both the Tropical and Subtropical countries in West Africa, the Carribeans, the Northerrn and Central part of South East Asia including parts of China, Malaysia, Japan and Oceania (Mignouna *et al*., 2003). The FAO (1989) estimated that the world production is around 20 million ton per year. Nigeria alone produces three quarter of the world total output of yams. Okigbo (2004).The tuber is the edible portion of yam and has high carbohydrate content, serving as a major source of energy but, low in fat and protein. Yam is consumed as boiled yam, pounded yam and fried yam or processed into flour. Morphological characterization is an important tool even in the era of molecular characterization because of its reliability and easy identification with less resources for certain stable characters unaltered by environmental interactions. Therefore the objectives of this study was to characterize 20 white yam genotypes based on morphological diversity in Umudike south eastern Nigeria.

MATERIALS AND METHODS
The field trial was conducted at the farm of the National Root Crops Research Institute (NRCRI), Umudike, South Eastern Nigeria in 2022. The field was prepared by slashing, ploughed and harrowed. The field was marked out into three replications and each replicate was divided in to 20 plots measuring 4m x5m (20m²). The spacing between each replicate was 1m and the spacing between each plot was 0.5m. The sett size was 100g of 20 different genotypes of white yam were the experimental treatments. The experiment was a Randomized Complete Block Design (RCBD) with three replications. Data were collected on 12 morphological characters from at least three healthy plants. Traits measurement and data collection procedure used was based on those presented in the International Plant Genetic Resources Institute's descriptor list for yam (IPGRI/ IITA, 1997) with slight modifications. Only those descriptors or traits that discriminated between genotypes were used in this study. Data were the average of at least three different healthy plants per genotype. Morphological character analysis was based on the "mathematics of information Theory" (Nwankwo 2014) which allows simultaneous analysis of both quantitative and qualitative data. Any character or state that is not in alliance with the column characters is discriminatory

RESULT AND DISCUSSION

The tubers of the twenty advanced yam genotypes were characterized for their morphological variability (Table 1). List of morphological characteristics and character states were based on yam descriptor manual code character, while morphological character analysis was based on the mathematics of information theory which allows simultaneous analysis of both quantitative and qualitative data (Nwankwo 2014). This method simultaneously group tubers that have corresponding biological similarity together in ranks. Any character or state that is not in alliance with the column character is discriminatory. At a glance in the table, duplicate genotypes can easily be detected out (Table 1). The result of the twelve principal characteristics namely flesh colour, number of tubers per plant, relationship of tubers, corm size, tuber length, texture of skin, hairiness of surface tuber, tuber spines, maturity of tuber and tuber habit were analyzed using the mathematics of information theory. The twenty white yam genotypes are uniform in relationship of tubers i.e. they are completely separate not fused, the flesh colour is white, Under tuber length, the twenty yam genotypes were uniform in that character. Their tuber lengths were from 20 to 100cm. As regard their tuber maturity and tuber habit, all the yam genotypes indicated that they were early maturing (7 months or less) and annual plants (that is can be harvested the same year). Other characters in the other six columns are discriminatory. Each column is a character while each row is a state (or genotype). All the 20 advanced white yam genotypes have the same four characteristics namely relationship of tubers, tuber length, maturity of tubers and tuber habit but there were remarkable variation in number of tubers per stand, corm size, texture of tuber skin, tuber shape ,hairiness of surface tuber, and spines. Each genotype differs from the other as they appear in their rows. Based on the result of Table 1, the morphological characterization using yam manual descriptor indicated that there is variation among the yam genotypes

Based on these morphological variations, the 20 genotypes are characterized into the following groups:

Group 1. Out of the 20 genotypes of white yam used,18 genotypes exhibit variation for number of tubers as normal one TDR 1439018, TDR 000021, TDR 090061, TDR 1414005,TDR 1440035,TDR 1436015, TDR 11/00585,TDR 1417015 ,TDR 000078, TDR 11/00396, TDR 89/02665,TDR 09/00082,TDR 1430007,TDR1429027,TDR 1439027,TDR OBIATURUGO, TDR 0000360, TDR 1428017),while 2 genotypes (TDR 1401593,TDR 100003) exhibits variation for few number tubers per stand.(Table 1)

Group 2. Out of the 20 genotypes of white yam used, there is morphological diversity in corm size,9 genotypes TDR 1436015,TDR 11/00585,TDR 1417015,TDR 09/00082,TDR 1430007,TDR 1429027,TDR 1439027,TDR OBIATURUGO,TDR 1428017 exhibits small corm size ,9 genotypes TDR 1439018, TDR 000021, TDR 090061, TDR 1414005, TDR 1440035, TDR 100003 TDR 000078, TDR 89/02665, TDR 0000360 exhibits medium corm size while only 2 genotypes TDR 1401593, TDR 11/00396 exhibits large corm size (Table 1)

Group 3. Out of the 20 genotypes of white yam used, there is variation in tuber length ranging from 6-20cm(2) to 21-100(3),5 genotypes TDR 1439027,TDR 1439018, TDR 100003, TDR 1430007, TDR 1429027 has tuber length of 6-20cm while 15 genotypes TDR 000021, TDR 090061, TDR 1414005, TDR 1440035, TDR 000078, TDR 89/02665, TDR 0000360,TDR 1436015,TDR 11/00585,TDR 1417015 ,TDR 09/00082, TDR OBIATURUGO, TDR 1428017,TDR 1401593, TDR 11/00396 has tuber length ranges from 21 to 100cm) Table 1

Group 4.Out of the 20 genotypes of white yam used, variation in texture of Tuber skin among the genotypes ranges from smooth to rough.18 genotypes TDR 1430007, TDR 1429027,TDR 000021, TDR 090061, TDR 1414005, TDR 1440035,TDR 89/02665, TDR 0000360,TDR 1436015,TDR 11/00585,TDR 1417015 ,TDR 09/00082, TDR OBIATURUGO, TDR 1428017,TDR 1401593, TDR 11/00396, TDR 1439027,TDR 1439018,are smooth(1) while only 2 genotypes TDR 100003, TDR 000078 are rough in texture of tuber skin.

Group 5. Out of the 20 genotypes of white yam used, variation in hairiness of surface ranges from absent, few and profuse, 5 genotypes TDR 100003, TDR 000078, TDR 89/02665, TDR 09/00082, TDR 1429027 has no hair on their surface,11 genotypes TDR 000021, TDR 090061, TDR 1414005, TDR 1440035, TDR 0000360, TDR 11/00585,TDR 1417015 , TDR OBIATURUGO, TDR 1428017,TDR 1401593, TDR 11/00396, has few hair on their surface while 4 genotypes TDR 1439018, TDR 1436015, TDR 1430007, TDR 1439027, has profuse hairiness on their surface.

Group 6. Out of the 20 genotypes of white yam used, there is diversity in spines on the yam tubers,15 genotypes TDR 09/00082, TDR 1429027,TDR 000021, TDR 090061, , TDR 1440035, TDR 0000360, TDR 11/00585,TDR 1417015 , TDR OBIATURUGO, TDR 1428017 , TDR 11/00396, TDR 1439018, TDR 1436015, TDR 1430007, TDR 1439027, has no spine on their surface,3 genotypes TDR 1414005, TDR 000078, TDR 1401593 has some spines on their surface while 2 genotypes TDR 100003, TDR 89/02665 has profuse spines on their surface.

Group 6. Out of the 20 genotypes of white yam used, their is diversity in tuber shape among the genotypes used,4 genotypes TDR 1439018, TDR 090061, TDR 1414005, TDR 000078 are oval long in shape,7 genotypes TDR 1401593, TDR 1440035 ,TDR 11/00396, TDR 11/00585, TDR 89/02665, TDR 1439027 ,TDR OBIATURUGO are oval in shape while 9 genotypes TDR 100003, TDR 09/00082, TDR 1429027,TDR 000021, TDR 0000360,TDR 1417015 , TDR 1428017 , TDR 1436015, TDR 1430007 are round in shape.

Table 1: Morphological Variations of Advanced white yam genotypes (tubers)

NAMES	Tuber Flesh Colour	No of Tubers Per Stand	Relationship of Tubers	Corm Size	Tuber Length	Texture of Tuber Skin	Hairness of Surface	Spineness	Maturity of Tuber	Tuber Habit	Tuber Shape	Skin Colour
TDR 1439018	1	1	1	2	2	1	1	1	2	1	4	4
TDR 000021	1	1	1	2	3	1	2	1	2	1	2	4
TDR 090061	1	1	1	2	3	1	2	1	2	1	4	4
TDR 1414005	1	1	1	2	3	1	2	2	2	1	4	4
TDR 1440035	1	1	1	2	3	1	2	1	2	1	3	4
TDR 1436015	1	1	1	1	3	1	1	1	2	1	2	4
TDR 11/00585	1	1	1	1	3	1	2	1	2	1	3	4
TDR 1417015	1	1	1	1	3	1	2	1	2	1	2	4
TDR 100003	1	2	1	2	2	2	3	3	2	1	2	4
TDR 000078	1	1	1	2	3	2	3	2	2	1	4	4
TDR 11/00396	1	1	1	3	3	1	2	1	2	1	3	4
TDR 89/02665	1	1	1	2	3	1	3	3	2	1	3	4
TDR 09/00082	1	1	1	1	3	1	3	1	2	1	2	4
TDR 1430007	1	1	1	1	2	1	1	1	2	1	2	4
TDR 1429027	1	1	1	1	2	1	1	1	2	1	2	4
TDR 1439027	1	1	1	1	2	1	1	1	2	1	3	4
TDR OBIATURUGO	1	1	1	1	3	1	2	1	2	1	3	4
TDR 0000360	1	1	1	2	3	1	2	1	2	1	2	4
TDR 1428017	1	1	1	1	3	1	2	1	2	1	2	4
TDR 1401593	1	2	1	3	3	1	2	2	2	1	3	4

Note: Each column is a character and the rows respective state or genotype

Coded List of Genotype States

(1).Flesh colour:1 = white, 2 = cream, 3 = yellow
(2) Hairiness of surface: 1 absent, 2 few, 3 profuse
(3).Number of tubers per stand: 1 = normal one, 2 = few (2-5), 3 = several (>5)
(4) Spineness: 1= none, 2= some, 3 = profuse
(5).Relationship of tubers: 1 = completely separate and Distant, 2= completely separate in close cluster, 3 = fused
(6). Maturity of tuber: 1= Early maturing: (7 months or less), 2 = Medium maturity more than 7 less than 10m, 3. Late maturity (more than 10 months)
(7).Corm size in relation to tuber size: 1 = small, 2 = medium, 3 = large
(8).Tuber habit: 1=annual, 2= perennial
(9).Tuber length: 1 = 1-5cm, 2 = 6-20cm, 3 = 21-100cm, 4 = >100cm
(10).Texture of tuber skin: 1= smooth, 2= rough
(11).Tuber Shape2=Round, 3=Oval,4=Oval long
(12).Skin colour, 1=greyish, 2= maroon,3=black,4=Brown

CONCLUSION

Findings shows that out of the twelve principal characteristics used, there is varuation among the 20 genotypes used, number of tuber per stand, corm size in relation to tuber size, tuber shape and hairiness of surface are good discriminant descriptor traits for characterizing yam tubers .This is because descriptors correspond to characteristics or attributes whose expressions are easily detected by the naked eye, be recorded, have high heritability, high taxonomic and agronomic value, easy to measure or evaluate (Hildago, 2003). Morphological characterization of plants is vitally imperative for the detection of desirable peculiar traits, identification of duplication, accessions and structuring of population for conservation (Manamela, 2009) The variations analyzed using "mathematics of information Theory" offer a bright scope for selection based on desirable morphological traits which can be used in future breeding purposes.

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GGE BI-PLOT ANALYSIS OF LARGE SEEDED CASTOR GENOTYPES IN NIGERIA

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ABSTRACT

Castor (Ricinus communis L.) expresses a wide-range of plasticity to changing in environment, hindering effective ranking of genotypes by mean performance. In the present trial assessment of performance and stability of some promising large seeded castor genotypes at eight locations in Nigeria. The trial was laid out on randomized complete block design with three replications. Results showed significant effects of genotypes, locations as well as genotype by locations interaction for seed yield, height at maturity, spike per plant and seed oil content. Pool means showed a range between 781.16 kg/ha and 1263.53 kg/ha among the genotypes. The GGE Biplots revealed that the eight locations could be grouped into two clusters. The genotype Acc001 (Gen3) out yielded others at five out of the eight locations. Genotype Acc001 and Genotype Acc045 showed better performance and stability among the evaluated castor genotypes.

Keynote: *Yield performance, Stability, Castor, GGE Biplot*

INTRODUCTION

Castor has a wide-range of variability for characteristics such as seed size (Wiess, 2000). The small seeded castor is commonly chosen if the interest is on the seed oil while the large seeded ones are preferred if the interest is on the product derived from seed endosperm (Salihu *et al.*, 2015). In Nigeria and some other parts of West Africa, the large seeded castors are used to produce '*Ogiri'* - a local condiment (Gana, 2015). The small seeded are not used for the condiment due to the drudgery involved in the removal of the seed coat and low endosperm yield. The condiment is a highly proteinous fermented food supplement traditionally consume by about 20% of the Nigerian population (Okeke *et al.*, 2009). The castor condiment has been reported to have 5.70 and 2.57-times higher protein content than pumpkin and snail respectively (Okeke *et al.*, 2009). The seed may also contain up to 60% oil content. The castor oil has a unique fatty acid composition which provide expanding utilization in many industries.

Despite the economic potential, castor improvement programme in Nigeria has not been receiving much attention, resulting in lack of improved production practices to the farmers (Amosun *et al.*, 2013). Low yield is a major limitation of production in Nigeria (Gana, 2015). Against average yield of 1,200 – 3,000kg/ha obtainable in other countries like India, China and Brazil; the average yield among farmers in Nigeria ranges between 300 kg/ha and 600kg/ha (Amosun *et al.*, 2013). Another major limitation in the country is poor and unorganized castor market (Salihu *et al.*, 2015). The major off take of castor seed in Nigeria presently are the local condiment producers and some cottage oil industries; thus, farmers have preference for the large seeded castor because of the available market. Therefore, the objectives of this research were to assess the yield performance as well as stability of some promising large seeded castor genotypes across eight locations in Nigeria.

MATERIALS AND METHODS

Eight (8) large seeded genotypes (including a check) were evaluated in 2016 and 2017 rainyseasons. The trials were arranged in a Randomised Complete Block Design (RCBD) with three replications. The genotypes were evaluated on plot size of 5m x 6m with a plant spacing of 1.00m by 0.75m. Two seeds were sown and later thinned to one stand per hill. Fertilizer at 60:30:30 kg/ha of N:P:K respectively was applied. Weeding was carried out at 3, 7 and 11 weeks after planting. The locations used were Badeggi, Minna, Zuru, Mokwa, Bacita, Riyom, Ibadan and Amakama. Yield Performances and Stability Analysis (GGE Biplot) for the multi-locational data was done following the procedure of a statistical package PBTools 1.3 version.

RESULTS AND DISCUSSION

A Significant contribution of genotypes to the variation in seed yield was recorded in all the locations (Table 1). Also, the pool ANOVA showed that there were significant differences in the seed yield and all other traits considered among the genotypes (Table 1). Significant effects of environments as well as genotype by environment were observed for seed yield and height at maturity (Table 1). Pool means showed a range between 781.16 kg/ha and 1263.53 kg/ha among the genotypes. The genotype Acc001 recorded the highest average seed yield of 1263.53 kg/ha while the least mean was recorded by the local check (i.e popular farmers' accession – not standard check). The significant effects of locations as well as G × E interactions observed for the seed yield and height at maturity have also been reported by Solanki and Joshi (2003) and Aher *et al.* (2015).

According to the GGE Biplots, a total of 84.3% (PC1 - 61.1% + PC2 - 23.3%) variation was attributed to the Principal Component Axis 1 and 2 (Figures 1, 2, 3). Ibadan and Mokwa locations showed the highest discriminating ability among the locations in the two clusters respectively (Figure 1). In terms of representativeness (location spread), Zuru (E8) Bacita with least angle to the average environmental axis (AEA) are the most representative of the two groups (1). The genotype Acc001 (Gen3) showed good stability and falls within the concentric cycle of ideal genotype, representing the most ideal genotype among the entries (Figure 2). The which-won-where biplot for the entries is presented in Figure 3. The genotype Acc001 (Gen3) out yielded others in Amakama (E1), Bacita (E2), Mokwa (E6), Riyon (E7) and Zuru (E8). Genotype Acco040 (Gen6) out yielded all others at Badeggi (E3) and Ibadan (E4). From the results of the performance and stability assessments, it is logical to recommend both Acc001 and Acc045 for on farm trials in both identified clusters of environments so as to exploit the opportunity of both broad adaptation and specific adaptation to the environments if any.

CONCLUSION

The results revealed wide range of yield performance means among the genotypes evaluated. Out of the 8 genotypes evaluated, genotype Acc001 and Acc045 were two best performing genotypes (for what)?? and could be recommended for farmers' adoption following multilocational On Farm Adaptive Research studies.

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Table 1: Pool means for seed yield and other agronomic traits of eight castor genotypes across eight (8) locations in Nigeria, 2016-2017

Genotypes	Day to Maturity	Height at Maturity (cm)	Seed Yield (kg/ha)
Acc.048	106.77	159.37	938.85
Acc.050	102.18	145.92	902.2
Acc001	109.45	141.12	1263.53
Acc020	171.37	250.85	815.7
Acc024	161.32	149.07	863.2
Acc040	98.16	186.7	992.18
Acc045	99.25	240.94	1060.85
Local Check	143.72	212.41	781.16
Mean	124.03	185.8	952.2
MS Locations (L)	8114.95	660.17**	2602095.24**

MS Block within	29158.25	301.52	15467.5
MS Genotypes (G)	43138.24*	93365.11**	1070249.84**
MS Year (Y)	2299.71	42.68	988173.33**
MS G x Y	7519.86	153.21	45577.42**
MS L x G	15042.92	1204.17**	274992.73**
MS L x Y	12880.17	26.02	179918.27**
MS L x G x Y	22775.72	282.13*	43398.35**
Pooled Error	19361.13	190.95	9830.41

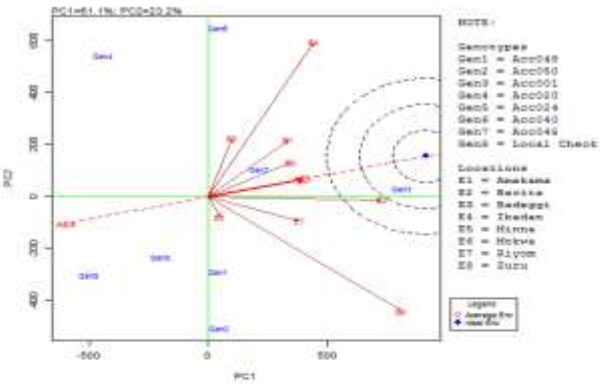

Figure 1: GGE Biplot showing representative/discriminating abilities of the eight locations considers

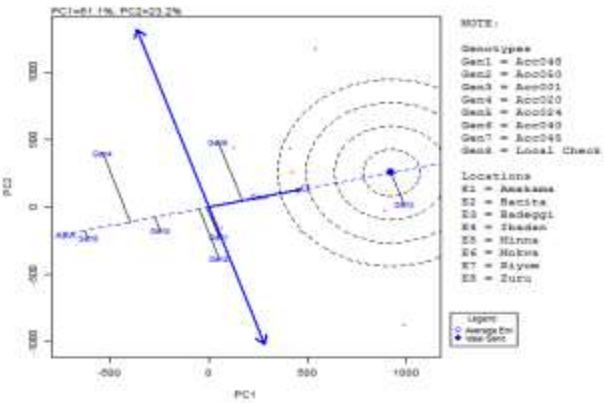

Figure 2 Mean performance and stability of the 8 castor genotypes evaluated across 8 Locations in Nigeria

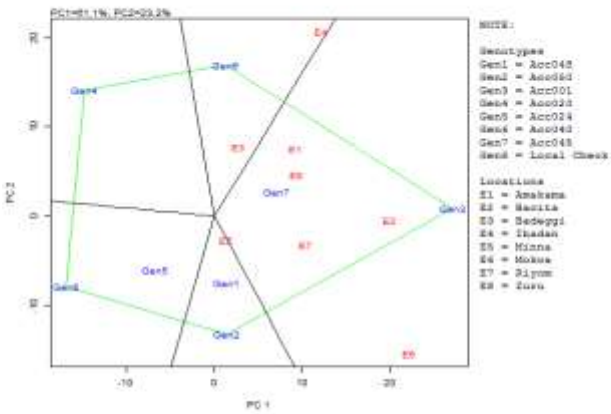

Figure 3: The which-won-where view of the GGE biplot

GENETIC DIVERSITY IN CASTOR GERMPLASM AT BADEGGI, NIGERIA

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ABSTRACT
Castor (Ricinus communis L.) is an important oil-crop, considered very critical for many industrial applications. In the present study, the genetic diversity in the available castor breeding lines at the National Cereals Research Institute Badeggi was assessed. The lines were evaluated on a replicated progeny row plots arranged in a randomized complete block design. The results showed variation for all the 8 agronomic traits studied among the entries. Days to First Raceme Maturity varied from 80 days to 118 days with average mean of 103.95 days. The length of the spike was between 15.40cm and 49.20cm among the lines. Height to First Raceme between 44.20cm and 135.4cm were recorded among the lines. The seed yield per plant among the lines was between 0.08 and 0.48 (kg/plant). Six cluster groups, with 2 to 20 members, were generated. Cluster III comprises of two early maturing lines (Line9 and Line43) with a range between 96 to 97 days. Populations with high seed yields could be constituted from the cluster I and IV. The cophenetic coefficient of 0.812 was obtained among the clusters. The results revealed optimum genetic distance among the breeding lines evaluated; therefore, they could serve as good parental materials for castor breeding in Nigeria.
Keywords: *Castor, Breeding lines, Genetic diversity, Nigeria*

INTRODUCTION
Castor oil plant (*Ricinus communis* L.) is an oil-crop considered very critical for many industrial applications because of its ability to form many important derivatives (Ogunniyi, 2006). The oil, which is extracted from the seed, is used in more than 700 applications, including the applications in pharmaceutical industries, rubber/plastic industries, and lubricants/biodiesel industries (Mutlu and Meier, 2010). In the southern part of Nigeria, a food condiment (*Ogiri*) among the Igbo tribe is produced from castor seeds (Salihu *et al*., 2014). The residual meal of castor seed, after detoxified by boiling, could be used as supplement feed in preparation of broiler finishing diets without any harmful effects (Ani and Okorie, 2009). Also, the meal (autoclaved) could be used in place of the soybean meal in sheep rations (Pompeu, 2009). Organic fertilizer produced from castor meal was reported to have advantage of high nitrogen content, fast mineralization and anti-nematode effects (Lima *et al*., 2011). The leaves, seeds and capsules of castor are used for traditional medicines (Gana, 2015). Concoctions prepared from the leaves and roots are used in the treatment of after birth weakness in baby.

Despite the huge economic benefits of castor, it's genetic improvement in Nigeria has not been receiving much attention. Consequently, the seed yield among Nigerian castor farmers is low in comparison with the average yields in other countries (Salihu *et al*., 2019). Therefore, there is the need for active castor research in Nigeria if the country is to exploit the potential of the crop for economic growth. With the availability of castor germplasm in some research centres like National Cereals Research Institute Badeggi, there are opportunities to increase the yield level of castor in Nigeria. However, for any successful genetic improvement programme, identification of appropriate parents is very crucial (Shivanna, 2008). Information on genetic diversity of available breeding lines is of high priority. Under these ideas, the present research was to assess the genetic diversity in the available castor breeding lines at the National Cereals Research Institute Badeggi, Nigeria.

MATERIALS AND METHODS
Seventy four selected improved breeding lines, sourced from the National Cereals Research Institute (NCRI) Badeggi, were evaluated at NCRI Castor Experimental Field Badeggi during 2020 raining season. The lines were evaluated on a replicated progeny row plots arranged in a randomized complete block design. Three replicated

plot size of 1m x 7m was used and plant spacing of 75cm and 1m for intra-row and inter-row respectively were adopted. Data were taken on Days to First Raceme Maturity, Number of Nodes, Number of leaf lobes, Leaf Length (cm), Leaf Petiole Length (cm), Spike Length (cm), Height to 1st Raceme (cm) and Yield/Ha (kg/ha). The genetic diversity among the lines was assessed through cluster analysis procedure of Statistical Package for Agricultural Research (STAR 4.0.1).

RESULTS AND DISCUSSION

The results revealed variations for all the studied traits among the entries. Days to First Raceme Maturity varied from 80 days to 118 days with average mean of 103.95 days. Number of internodes to First Raceme ranged between 11 and 21. The length of the spike was between 15.40cm and 49.20cm among the lines. Height of 44.20cm to 135.4cm was recorded among the lines for Height to First Raceme (cm). The seed yield per plant recorded among the lines was between 0.08 and 0.48 (kg/plant). Agglomerative cluster dendrogram constructed from morphological data among the lines is presented in Figure 1. The summary statistics for the agronomic performances of the cluster groups is shown in the Table 2. Six cluster groups, with 2 to 20 members, were generated (Figure 1 and Table 1). The cophenetic coefficient was 0.812, signifying optimum genetic distance among the lines. Cluster I was the largest groups with 20 cluster members. Cluster III comprises of two early maturing lines (Line9 and Line43) with a range between 96 to 97 days; however extra-early maturing lines of about 80 to 84 days could be sourced from the cluster V, IV and VI (Table 1). Short height to first raceme could be found among the members of the cluster V and VI. Parent with long spike could be sourced within the members of the cluster III. Populations with high seed yields could be constituted from the cluster group I and IV.

Genetic improvement in any crop can be accomplished only if there is optimum diversity in the breeding populations. The findings from the present study indicate adequate variability for the traits studied. Golakia *et al.* (2015) also documented variability for most of characters reported in this study. Assessments of castor genetic diversity and phenotypic variability through several methodologies have been reported by several authors (Allan *et al*., 2008; Rao *et al.,* 2006 and Zheng *et al.*, 2010). Anjani and Reddy (2003) reported high divergence among twenty-one castor genotypes for yield and yield attributes. In a study on genetic diversity among nine castor accessions, Costa and Pereira (2006) distinguished two clusters and said that the prominent variability to the diversity among the accessions were contributed by days to flowering, raceme length, plant height and seed oil content. Zhang-Xishun and Yang-Jian (2006) considered forty-six castor germplasm and distinguished four clusters with no geographic clustering pattern.

CONCLUSION

From the findings of the study, it is shown that the breeding lines evaluated are divergent in nature and they could serve as good parental materials for castor breeding in Nigeria.

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Table 1: Summary Statistics for Agronomic Performances of the Cluster Groups Generated among 74 Castor Lines

Variable	**Cluster I**		**Cluster II**		**Cluster III**		**Cluster IV**		**Cluster V**		**Cluster VI**	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Days to Flowering	103.00	118.00	99.00	117.00	96.00	97.00	83.00	109.00	80.00	107.00	84.00	111.00
Height to First Raceme	71.00	135.40	61.80	130.60	62.40	96.80	63.60	114.60	44.20	96.60	48.20	92.80
Leaf Length (cm)	18.40	26.60	17.60	27.20	19.60	22.60	16.20	22.40	19.60	41.60	22.60	49.20
Number of leaf lobes	8.20	10.00	8.00	10.00	8.60	9.40	8.40	9.80	8.00	9.00	7.80	9.20
Number of Internodes	12.40	21.00	14.20	19.20	11.80	12.60	13.60	17.80	11.40	16.00	13.80	17.00
Petiole Length (cm)	15.40	23.00	14.40	21.20	16.60	22.60	12.60	20.60	16.20	21.20	22.60	28.60
Spike Length (cm)	17.00	35.40	15.40	24.80	29.60	39.60	19.00	32.00	12.00	17.80	15.00	20.80
Seed Yield (kg/plant)	0.16	0.48	0.09	0.33	0.17	0.20	0.21	0.40	0.08	0.28	0.10	0.18
	20 Line1 Line2 Line3 Line6 Line10 Line11 Line14 Line15 Line18 Line23 Line24 Line26 Line27 Line32 Line35 Line38 Line45 Line47 Line48 Line49		18 Line4 Line5 Line7 Line8 Line20 Line21 Line22 Line28 Line30 Line31 Line33 Line36 Line37 Line40 Line46 Line50 Line51 Line53		2 Line9 Line43		13 Line12 Line13 Line16 Line17 Line19 Line25 Line29 Line34 Line39 Line41 Line42 Line44 Line52		10 Line54 Line63 Line64 Line65 Line66 Line68 Line70 Line71 Line72 Line73		11 Line55 Line56 Line57 Line58 Line59 Line60 Line61 Line62 Line67 Line69 Line74	

COPHENETIC CORRELATION COEFFICIENT = 0.812

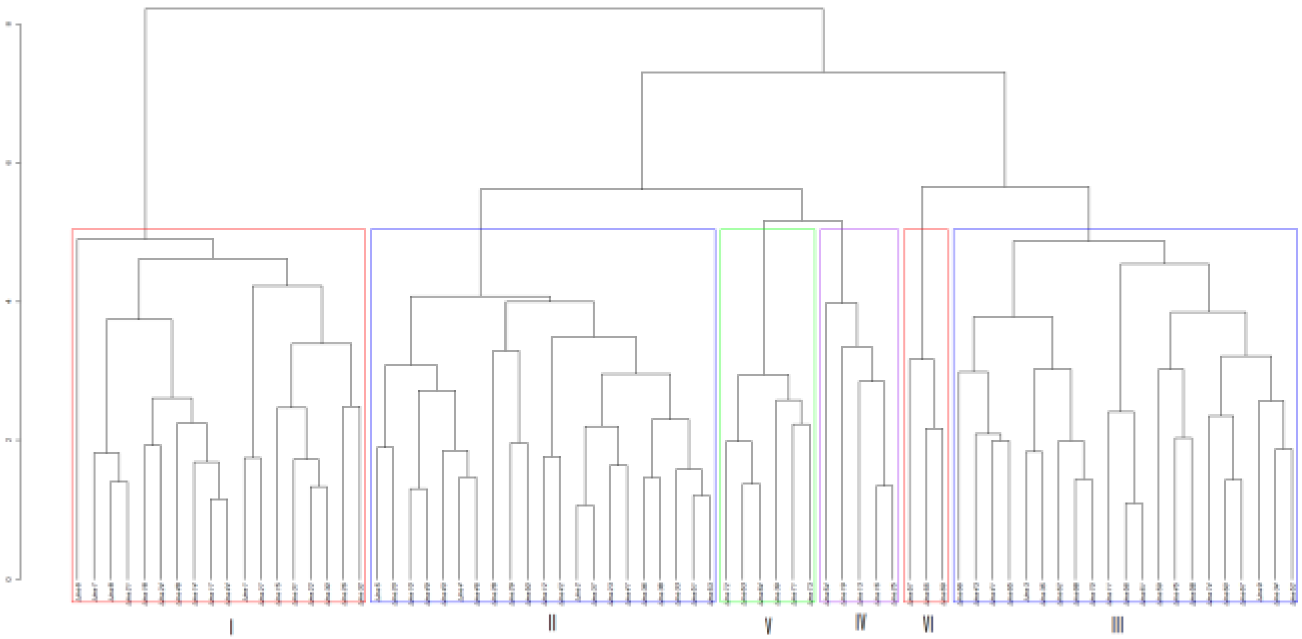

Figure 1: Dendrogram Constructed from 8 Morphological Traits of 74 Castor Breeding Lines at Badeggi, Nigeria

GENETIC ANALYSIS OF SELECTED YELLOW ROOT CASSAVA GENOTYPES AT ADVANCED YIELD TRIAL OF BREEDING STAGE IN UMUDIKE

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ABSTRACT
Cassava is crucial for food security which has great potential to contribute to African development and is increasing its income-earning potential for small-scale farmers and related value chains on the continent. This study was conducted at National Root Crops Research Institute, Umudike to evaluate genetic analysis of selected yellow root cassava genotypes at advanced yield trial in a randomized complete block design with three replications. The analysis of variance shows significant difference among genotypes for cassava mosaic disease (CMD), harvest index (HI), fresh root yield (FRY) and dry root yield (DRY). In terms of fresh root yield, genotypes NR170199 (21.13t/ha), NR170065 (21.60t/ha), NR170190 (21.66t/ha), NR170164 (23.00t/ha), NR170166 NR170007 (29.13t/ha), and NR170166 (32.53t/ha) performed better while genotypes NR170183 (30.02%) NR170207 (30.77%), and NR170146 (31.16%) had dry matter content better than the two check varieties (TME419&TMS070539). Six genotypes had total carotene content (TCC) better than the mean while NR170005 (9.23 µg/g) and NR170065 (9.54 µg/g) performed better than the checks UMUCASS46 (9.20 µg/g) and TME 419(1.44 µg/g). Also, all the genotypes were susceptible to cassava bacterial blight (CBB) and cassava anthracnose disease (CAD). A significant positive correlation was observed between harvest index and fresh root yield (r = 0.65374), but negatively correlated to total carotene content (r = -0.37469); FRY was negatively correlated to dry matter content (r = -0.14163) and TCC (r = -0.26025) while DMC was also negatively correlated to TCC (r = -0.00501).

Keywords: *Agronomic parameters, yellow root, location, disease, design*

INTRODUCTION
The increase in demand by fast expanding feed and starch markets as well as other cassava based industries across the globe and rising prices of close substitutes like rice and maize are rapidly re-ordering the dynamics of cassava market in the tropics of Africa, Asia and Latin America (Market Research Future, 2020; Ikuemonisan *et al*., 2020). A highly tolerant cassava crop known for its wide ecological adaptability will always perform relatively well where other crops may not be able to produce reasonable yield (Otekunrin and Sawicka, 2019). This attribute confers on cassava a reliable food security for farming households in the tropics (Ikuemonisan *et al*., 2020) in addition to providing dietary energy for close to a billion people and livelihood for millions of farmers/processors traders worldwide (FAO, 2018; Ikuemonisan *et al*., 2020). According to FAO (2018), cassava is a choice crop for rural development, poverty alleviation, economic growth and ultimately, food security. It is in view of the above that critical stakeholders have continued to contribute immensely to shaping the development of cassava sub-sector in Nigeria. The objectives of the study were to determine: (i) the influence of genotypes on fresh root yield (FRY), dry root yield (DRY), dry matter (DM), cassava mosaic disease (CMD), cassava bacterial blight (CBB), cassava anthracnose disease (CAD),cassava greenmite (CGM) and total carotene content.

MATERIALS AND METHOD
Selected twenty yellow genotypes selected from the preliminary stage and two checks (TME419 and UMUCASS46). Cassava planting stakes of 20-30 cm in length were planted on July 2020 laid out in Complete Randomized Block Design with a plot size 4m × 7m. The experiment was replicated two times. A planting distance of 1 m x 1 m was maintained making 28 stands per plot. Pre and post-emergence herbicide was used after planting. Weeding of the farm was done manually. The plants were scored for resistance to major cassava disease and pests

1,3,6,9 and 12 MAP. Determination of dry matter, fresh root yield, dry matter content, and dry root yield of the cassava genotypes were carried out at harvesting using specific gravity method.

Statistical analysis

The data collected were subjected to analysis of variance (ANOVA) using General Linear Model (GLM) procedure in SAS software, 2002 to test for the treatment of effect and significant interaction of the variables considered.

RESULTS

The analysis of variance shows significant difference among genotypes for cassava mosaic disease (CMD), harvest index (HI), fresh root yield (FRY) and dry root yield (DRY) (Table 1). Nine genotypes had fresh root yield better than the checks and genotype means (19.50t/ha). Genotype NR170166 shows the highest FRY of 32.53t/ha while NR170183 revealed the least value of 11.40t/ha. Genotype NR170146 had the highest dry matter content (31.16) while NR170168 had the least valve (26.64%)(Table 2). However, three genotypes had DMC as from 30.00% above; and perform well better than TME419 and TMS070539 and the genotype mean (28.30%) (Table 2). Nine genotypes were not infected with cassava mosaic disease while seven genotypes were susceptible; all the genotypes were susceptible to cassava bacteria blight (CBB) and cassava anthracnose disease (CAD) (Table 2) .Total carotene content ranged from 5.25µg/g to9.54 µg/g with NR170065 recording the highest value of 9.54 µg/g and NR170009 with the least value of 5.25µg/g. Six genotypes had TCC better than the mean while NR170005 (9.23 µg/g) and NR170065 (9.54 µg/g) performed better than the checks UMUCASS46 (9.20 µg/g) and TME 419(1.44 µg/g) (Table 2) .A significant positive correlation was observed between harvest index and fresh root yield (r = 0.65374***), but negatively correlated to total carotene content (r = -0.37469); FRY was negatively correlated to dry matter content (r = -0.14163) and TCC (r = -0.26025) while DMC was also negatively correlated to TCC (r = -0.00501) Table 3.

Table1. Analysis of variance of yellow root cassava genotypes reaction to disease, pest and yield Components at advanced yield trial in Umudike

SOURCE	DF	CMD	CBB	CAD	CGM	HI	FRY (t/ha)	DMC (%)	DRY (t/ha)
REP	2	0.19ns	0.16ns	4.59ns	0.00ns	0.00ns	3.72ns	8.04ns	0.45ns
GENOTYPES	21	1.12***	0.16ns	98.92ns	0.03ns	0.04***	86.51***	10.40ns	6.50***
ERROR	38	0.19	0.11	40.11	0.03	0.00	18.38	5.78	1.49
CV%		30.30	18.59	36.06	17.34	6.93	23.38	8.58	23.88
R^2		0.77	0.55	0.60	0.37	0.95	0.72	0.53	0.70

*(P<0.05), ** (P<.001), *** (P<.0001), ns- not significant, CMDS: cassava mosaic disease, CBB: cassava bacterial blight, CAD: cassava anthracnose disease, CGM: cassava greenmite, DMC: dry matter content, FRY: fresh root yield, HI: harvest index, CV: coefficient of variation

Table 2. Mean reaction of selected yellow root cassava genotypes to disease and yield attributes at advanced yield trial in Umudike

GENOTYPES	CMD	CBB	CAD	FRY (t/ha)	DMC (%)	TCC(µg/g)
NR170007	1.00	2.00	2.33	29.13	26.91	5.26
NR170009	1.00	2.00	2.33	19.60	28.89	5.25
NR170005	3.00	2.00	2.00	11.86	29.82	9.23
NR170207	2.33	2.00	2.33	19.60	30.77	6.06
NR170174	2.33	2.00	2.33	19.66	26.53	6.86
NR170164	2.33	1.66	2.00	23.00	27.42	6.94
NR170168	2.00	1.33	2.33	17.26	26.64	6.68
NR170183	1.66	1.66	2.33	11.40	30.02	7.07
NR170199	1.33	2.00	2.33	21.13	28.07	6.26
NR170144	1.00	2.00	2.00	16.80	28.14	6.11
NR170065	1.00	1.66	2.00	21.60	28.55	9.54
NR170146	1.00	2.00	2.33	15.26	31.16	8.81
NR170166	1.00	1.33	2.00	32.53	27.43	7.96
NR170021	1.00	2.00	2.33	17.13	25.40	8.60

NR170190	1.00	2.00	2.33	21.60	28.45	5.98
NR170151	1.00	1.66	2.33	18.73	29.32	9.08
TME419	1.66	2.00	2.00	17.46	28.31	1.44
UMUCASS46	1.00	2.00	3.00	16.86	28.41	9.20
MEAN	1.50	1.90	2.30	19.50	28.30	7.00
STDEV	0.63	0.23	0.24	5.05	1.47	1.94
CV%	42.00	12.10	10.43	25.89	5.19	27.71

CMDS: cassava mosaic disease, CBB: cassava bacterial blight, CAD: cassava anthracnose disease, DMC: dry matter content, FRY: fresh root yield, HI: harvest index, CV: coefficient of variation, STDEV: standard deviation, TCC: total carotene content

Table 3: Correlation among yield related traits of selected yellow root cassava genotypes evaluated at advanced yield stage of breeding in Umudike

SOURCE	HI	FRY(t/ha)	DMC (%)	TCC (µg/g)
HI	....	0.65374***	0.09060	-0.37469
FRY (t/ha)	....	....	-0.14163	-0.26025
DMC (%)	....	....	....	-0.00501
TCC (µg/g)	....	....	....	....

*(P<0.05), ** (P<.001), *** (P<.0001), ns- not significant, FRY: fresh root yield, DMC: dry matter content, TCC: total carotene content, HI: harvest index

CONCLUSION

The results showed that all the genotypes were susceptible to cassava bacterial blight (CBB) and cassava anthracnose disease (CAD). In terms of fresh root yield, genotypes NR170007 (29.13t/ha), NR170009 (19.60t/ha), NR170207 (19.60t/ha), NR170174 (19.66t/ha), NR170164 (23.00t/ha), NR170199 (21.13t/ha), NR170065 (21.60t/ha), NR170166 (32.53t/ha), NR170190 (21.66t/ha) and NR170151 (18.73t/ha) perform better while genotypes NR170183 (30.02%) NR170207 (30.77%), and NR170146 (31.16%) had dry matter content better than the two check varieties (TME419&UMUCASS46).Genotypes NR170005 (9.23µg/g) and NR170065 (9.54µg/) had total carotene content better than the checks

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EFFECT OF DIFFERENT MEDIA ON MYCELIAL GROWTH OF *PLEUROTUS OSTREATUS*

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ABSTRACT

A preliminary experiment was carried out to analyse the growth performance of *Pleurotus ostreatus* mushroom *cultures using chemosynthetic media. The objective of the study aimed to differentiate media such as Potato Dextrose Agar (PDA), Malt Extract Agar (MEA), Corn Meal Agar (CMA) and Czapex Dos Agar(CDA) on the growth of Pleurotus ostreatus mycelia. The study revealed that all the media had a significant growth from day 2 –day 8 at different growth level. There is equally a growth different between all the growth media as the incubation days increases. Malt Extract Agar had the highest mycelial density of 5+ and (5.7mm per day) with CMA being the least for mycelial density of 1+ growth rate with 5.0mm per day. At Day 6, PDA had 34.00mm radial growth of mycelial, MEA had 35.00mm, CDA with 30.00mm while CMA had mycelial growth of 26.00mm. The best out of the four growing media used is MEA (40mm), followed by PDA (39mm) while the least is CMA (35mm) (MEA>PDA>DOX>CMA). All the used media excluding CMA had averagely a good mycelia density growth (2+ -5+) and can support the growth of Pleurotus ostreatus mycelia in the Laboratory depending on their availability. This information would be important for researchers that needs to maintain mushroom in the laboratory for further study and equally for starter culture for farmers before using media derived from agro-residue to increase the productivity of mushroom mycelia for commercial purposes.*

Keyword: *Pleurotus ostreatus, mushroom,Malt extract agar media*

INTRODUCTION

Mushroom, a macro fungus with a distinctive fruiting body, is a unique biota which assembles its food by secreting degrading enzymes. Oyster mushroom grows wild on logs and stumps of trees in forests that fell or cut down. It belongs to the class Basidiomycetes subclass Hollobasidiomycetes, order Agricales and family Pleurotaceae (Alexopolous and Mims, 1996) and comprises about 40 species (Chang, et al., 1998). They are widely used as delicacies in different parts of the world because of their excellent flavor and taste (Jonathan and Esho, 2010). Mushroom growth is highly influenced by several factors such as spawn, growing media, pH, temperature, moisture content and light intensity (Kadiri and Kehinde, 1999). Storage and maintenance of mushroom species in a pure, viable and stable condition is essential for their use as reference strain, both in research and industrial scales (Bhatt et al., 2010). The identification of suitable agar media, substrate and incubation temperature is essential to obtain high yield and quality of mushroom.(Hasan et al., 2015). Mushrooms are good sources of sugars, fiber, protein and minerals (Senadore, 1990), with comparable amino acid with animal protein (Yang, et al., 2002). Mushroom cultivation is an eco-friendly method of solid waste management. It is evident that mushroom cultivation helps in the biological degradation of natural resources and are eco-friendly, protein rich food and the recent developments in the scientific understanding of mushroom cultivation has aided in improvement of its cultivation technology (Puri, 2011). Shiitake mushroom species are the edible mushroom which have originated from East Asia and cultivated and consumed in numerous Asian nations. Shiitakes give good amounts of protein (18%), potassium, niacin and B vitamins, calcium, magnesium and phosphorus. Furthermore, mushrooms contain a great quantity of dietary fiber and given their chemical structure, they show immunostimulatory and anticancer activity (Cheung 2013). The availability of the agro-residues after crop harvest like straws of various crops as that of wheat, sorghum and rice has been used as a basal substrate for the cultivation of shiitake in recent times. *Lentinula edodes* is a white rot fungus that secretes a class of ligno-cellulolytic enzymes, which permit it to grow on ligno-cellulosic substrates rich in lignin (Barros, et al., 2006). The use of locally available agro-residues provide a way to minimise the cost of cultivation and also helps to reduce the environmental pollution that occurs due to burning of various agro-residues in the field after the harvest. The growth of Shiitake was found faster on agro-residues compared to the natural log cultivation but with drawback of contamination of mycelia (Puri, 2011).Malt extract agar, Potato dextrose agar and Czepa dox agar are media with growth chemical requirements for fungi growth. With this background the present study is undertaken to evaluate the effect of different synthetic media on growth of (*Pleurotus ostreatus*) shiitake mushroom for mycelial growth.

MATERIALS AND METHODS

The present investigation was carried out at Plant Pathology Laboratory, National Root Crops Research Institute, Umudike, Abia State, Nigeria. The pure culture (mycelia) of *Pleurotus ostreatus* used for the present investigation was obtained from Plant Science and Biotechnology Department, Michael Okpara University of Agriculture, Umudike and was subsequently evaluated for the growth of its mycelial.

Sterilization of medium: The flasks having media were sterilized in the autoclave at 121^0c for 15 minutes and then poured in 90 mm Petri dishes under the laminar flow hood to avoid contamination. Media were cooled to 47ºC. The cork borers used for inoculation were sterilized through the flame of Bunsen burner. The experiment was repeated for 3 times.

Media preparation

All the media used – Malt extract agar, Potato dextrose agar, Corn meal agar and Czapek dox agar are produced aseptically according to the manufacturers instruction by dispensing the proper amount of media into one liter of distilled water and sterilized in an Autoclave at 121^0C for 15 minutes.

Purification of the *Pleurotus ostreatus* into Pure culture

Potato dextrose agar (PDA) medium was prepared by using 39g of potato dextrose agar in a litre of sterile distilled water and was sterilized at 121 ºC for 15 min. The medium was left to cool (45^0c) before 10 ml of the PDA preparation was dispensed into sterile petri dishes and allow to solidify. A small disc of tissue was collected from the culture of *Pleurotus ostreatus* mushroom and transferred onto the sterilized PDA medium under aseptic conditions. This was incubated at 27±2ºC for 8-10 days for sufficient mycelial growth. Pure cultures were obtained by subsequent sub culturing. Test tube containing the 10 ml sterilized PDA were kept in a slanted position and the purified cultures were sub cultured therein. They were later stored in the Regenerator.

Mycelia Inoculation Onto Media

All the four media were aseptically prepared, poured into sterile petri dish and allow to solidify. A flamed and cooled 5mm cork borer was used to pick the purified mushroom and transferred unto all the test media (inoculate). The plates were incubated at 25^0C and observed for 8 days during which the mycelial vegetative growth and mycelial density of ***Pleurotus ostreatus*** were recorded. The mycelial density was rated as described by (Kadiri, 1998) as follows:

+ = Very Scanty mycelial density
2+ = Scanty mycelial density
3+ = Moderate mycelial density
4+ = Abundant mycelial density
5+ = Very abundant mycelial density

The growth rate is given by the formula below:

Growth rate=Colony diameter on the last day (cm) /Number of day's measurement was taken after inoculation. Daily mycelial growth was determined using a ruler across the Petri-dish horizontally. (Kadiri, 1998)

Statistical Analysis

The observations were recorded after one week on the growth length of mycelia and were subjected to SAS Software at 0.05 probability level. CRD design was used with 3 replications under standard laboratory conditions.

RESULTS AND DISCUSSION

Table 1: Growth Rate of *Pleurotus Ostreatus* Mycelia on Different Media for Eight Days

			mm/day					
MEDIA	1	2	3	4	5	6	7	8
PDA	0.20±0.21	0.80±0.21	15.00±0.19	22.00±0.23	25.00±0.15	34.00±0.21	38.00±0.32	39.00±0.37
CMA	0.00±0.19	0.30±0.40	13.00±0.39	17.00±0.27	20.00±0.29	26.00±0.31	32.00±0.30	35.00±0.32
MEA	0.20±0.36	0.70±0.26	10.00±0.31	19.00±0.60	25.00±0.85	35.00±1.65	39.00±1.76	40.00±1.66
DOX	0.00±0.23	0.50±0.36	12.00±0.68	17.00±0.52	22.00±0.52	30.00±0.54	35.00±0.48	38.00±0.33

The results on the growth of *P.ostreatus* mycelia on the four media used are depicted in the Table 1 revealed that when compared the means against standard deviation, all the media had a significant growth from day 2 to day 8 at different levels. It also showed that the highest growth rate after 7 days of incubation was observed in Malt extract agar (MEA) (40.00mm) whereas lowest growth rate was observed on CMA (35.00mm). The effect of media on the radial growth of the fungus was influenced greatly by the kind of media used. Malt extract agar was most favoured by the strains followed by potato dextrose agar and the least CMA with the growth of 35mm. The mycelia growth of *P. ostreatus* on MEA and PDA showed a good mycelia growth from day 2 (0.70 and 0.80mm) respectively. Both Corn meal agar and DOX equally had a poor mycelia growth from day 2 with (0.30 and 0.50mm) respectively.

Table 2: Mycelial Density and Growth Rate of *P.ostreatus* Mycelia in Different *Medium*

S. No	Medium	Average Mycelial Density on 8th Day of Incubation	Growth Rate mm/day
1	Potato dextrose agar	4+	5.6
2	Corn meal agar	1+	5.0
3	Malt extract agar	5+	5.7
4	Czapek dos agar	3+	5.4

The result on mycelia density and growth rate on *P. ostreatus* in (**Table 2**) on the 8th day showed that Malt extract produced the highest mycelial density (5+) and growth rate of (5.7mm/day) followed by PDA media with 4+ and 5.6mm/day being mycelial density and growth rate respectively. On DOX media, mycelial density 3+ and growth rate was 5.4mm/day. The least growth was recorded on CMA media with 1+ as mycelial density and 5.0 mm/day as growth rate. Corn meal agar had a very poor mycelia density according to mycelia density rating while MEA medium proved to be the highest according to the density rating with 5+

Among the four solid growth media, malt extract agar media was found to support fastidious growth of mushroom cultures with the presence of higher amount of carbohydrates particularly maltose, protein and other medium. This is followed by potato dextrose agar medium, Czapek dox agar medium and Corn meal agar medium. Though the mycelial diameter of the mushroom culture in corn meal agar medium was at par with rest of the growth media, but the density of the mycelia was low when compared with the other three media. Thus, malt extract agar medium was found to be an ideal media for growth of these mushroom cultures. Mycological peptone present in the malt agar gives a luxuriant growth with typical morphology and pigmentation. The production of pigments by edible filamentous fungi is gaining attention as a result of the increased interest in natural sources with added functionality in the food, feed, cosmetics, pharmaceutical and textile industries.(Gmoser, *et al*., 2017) Mycelium is an important part for mushroom production as well as for production of several secondary metabolites used for therapeutic purpose. The mycelium growth depends on several factors such as growth media, pH, temperature, nutrient elements and some environmental factors (Calam, 1971). Growth medium is the most important factor because it supplies necessary nutrient for the growth of mushroom mycelium. Different media such as potato dextrose agar, yeast extract agar, malt extract agar, lamberts agar, Czapek dox agar and compost extract agar are mostly used for the growth of mycelium (Pathak, 1998). Gmoser et al, 2017 worked on pigmentation production by edible filamentous fungus and discovered that five factors are particularly important regarding pigment production namely carbon source (glucose and mannose), nitrogen source ($NaNo^3$ or NH_4CL) and trace metals ($Mg^{2+,}Mn^{2+}$ and Zn^{2+}.Malt extract had high source of carbon and protein source which gives it an edge in growth than other media used. Mycelium growth is the best tool to identify necessary nutrients for the production of fruiting bodies as mycelium growth requires short time in comparison with fruiting bodies development Kalmis and Kalyoncu ,(2006).

CONCLUSION

The study showed that Malt extract agar, Potato dextrose agar, Czapek dox agar and Corn meal agar are good in the production of mushroom mycelia as starter culture in the Laboratory but Malt extract agar had higher mycelial density than the other media used. Since mushrooms are good source of bioactive compounds of anticancer, antifungal and anti-diabetic in nature, the mycelia may be used for the large scale production of the compounds as mushrooms are seasonal. To make the bioactive production technology cost effective, present study may be useful in order to obtain more biomass ultimately to have bioactive compounds in hand. Further standardization regarding quantification of substrate as nutritional source for biomass production and its cost economics is required to reach more constructive conclusion.

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GENETIC VARIABILITY OF TOLERANCE TO HEAT STRESS IN BREAD WHEAT USING AGRONOMIC PARAMETERS (*TRITICUM AESTIVUM* L.).

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ABSTRACT

Heat is a serious production challenge to wheat in Nigeria, sufficient genetic variability is a prerequisite for development of heat tolerant varieties. To adapt and mitigate the adverse effect of heat on wheat, this study was designed with the objective to determine genetic variability in bread wheat for heat tolerance. Ten wheat genotypes obtained from Lake Chad Research Institute was sown at Hadejia sub station, during dry season of 2019 and 2020 (late period, December 25). Agronomic and yield attributes were evaluated at different crop growth stages. Results revealed significant ($p \leq 0.01$) difference among genotypes for days to heading, plant height, grain yield per plot and grain yield per hectare. Results revealed significant variation between the genotypes for the traits measured. Estimates of phenotypic coefficient of variation (PCV) were generally higher than genotypic coefficient of variation (GCV), with lower range indicating that apparent variation for these traits may not only be due to genotypes but also due to the little influence of environment. Likewise, heritability estimates were higher moderate-high for all traits except days to maturity which depicted low of heritability estimate. Mean performance for grain yield indicated that genotype (29526) was the best yielder in 2019 (4.95 Kg/ha), in contrast to observed performance in 2020, genotype (29642) which recorded the highest yield in 2020 (4.77 kg/ha).

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a member of the poaceae family with chromosome number 42 and a self - pollinated crop, it is one of the principal cereal of the world, fulfilling the maximal carbohydrates dietary requirement (Kumar *et al.*, 2013). Wheat contain 70% carbohydrates, 12% water, 2% fat, 12% protein, 1.8% minerals, and 2.2% crude fiber are found in wheat grain kernel. It is also enriched with phosphorus, magnesium, manganese, zinc, selenium, iron, potassium and copper (Liu et al., 2012). Industrially, wheat is utilized for, bio-ethanol production, succinic acid production, like a blend for baked products (bread, cake, crackers, cookies, pastries), pastas (spaghetti, macaroni) as nutritional improvement, for cosmetics, meat substitute, malt, alcohol, dextrose, gluten, neutraceutical/ pharmaceutical products, animal feed and for many more others (Yemsrach *et al.*,2015; William *et al.*, 2021).

Global wheat production stands at 772.30 million metric tons on about 215.90 million hectares (Mha) in 2019 (FAOSTAT, 2019). China is the top producing country in the world in 2019; it accounts for 134.3 m mt (21.9% of the world wheat production (F.A.O, 2020). In Africa, wheat production stands at 27 mt on about 9.8 million hectares, the major producer include Egypt (9.0 mt), Morocco (4.03 mt), Ethiopia (5.3 mt) and Algeria (3.7 mt) (FAO, 2019).

Nigeria production currently hovering around 60,000 tons from 56,080 hectares with an average yield of 1.06 t/ha while demand stands at between 4.5 and 5.0 mt (FAOSTAT, 2019, USDA, 2022). A recent report on wheat production in Nigeria by the National Bureau of Statistics, which conducted a survey that covered the 2020/2021 farming season across 13 states in Nigeria, said wheat production in Nigeria was 36,943.80 tonnes, a decrease of 23 percent from 60,000 tonnes as captured in the Agriculture promotion policy's strategy document of 2016, in that same year demand was put at 4.7 mt. But seven years later, while demand has largely grown, production declined. Nigeria imported wheat worth N1.3 trillion in 2021, an increase of 71% from N756.9 billion in 2020 (Odifa, 2023).

Despite the economic importance of wheat, its production is constraint by abiotic factors, principally high temperature which accounted for about 30% of 50% yield losses in wheat (Oerke *et al*., 1994 and Thilert, 2006) which are increasing in intensity and frequency associated with climate. The optimum temperature for wheat germination is between 20˚C - 22˚C whereas, during the grain development, the mean maximum temperature between 25˚C - 32˚C is considered moderately high and temperature between 35˚C - 40˚C is considered as very high temperature (Bano and Khan, 2021). Thus, it was reported that a rise in temperature of 1˚C in the wheat growing season reduced wheat yield by 3% - 10%.In the present era, the breeding for heat tolerance in wheat is one of the big challenges for breeders. To resolve this problem, there is need for knowledge on the selection of heat tolerant genotypes to respond to changing environments. This study is designed to screen wheat genotypes for development of desirable wheat genotypes for high temperature areas.

MATERIAL AND METHODS

Ten wheat genotypes along with a check were evaluated Randomized Complete Block Design (RCBD) on 3m x 2m late sown at the research farm of Lake Chad Research Institute Hadejia, during dry season of 2019 and 2020 cropping seasons. The experiments were sown using drilling method with three replications, spaced at 30cm between rows. Field management and other agronomic management practices such land preparations, sowing, weeding, fertilizer application, irrigation, harvesting e.t.c were observed based on recommendations. Data were recorded on agronomic traits viz, days to heading, days to maturity, plant height, yield per plant and grain yield per hectare.

Data Collection

Plant height (cm) Plant height was recorded at 12 weeks after sowing. This was obtained by measuring plant from the base to the tip of the plant using metre rule.

Days to 50% heading: Days to 50% heading was recorded as the number of days from planting when 50% of plants in the plot had their head emerged.

Days to maturity: Days to maturity was recorded as the number of days from planting when the plants in the plot had attained physiological maturity.

Grain yield (kg/ha): This was determined by weighing grains from the net plot, divided by net plot area and multiplies by 10,000.

$$\text{Grainyield} = \frac{\text{Seed yield/netplot}}{\textit{Net plot area}} \times 10{,}000$$

Data collected for each character were subjected to analysis of variance (ANOVA) using procedure of general linear model of SAS software 24 version 9.0 and treatment means were tested as significant at 5% probability level and as highly significant at 1% probability level. Mean comparison among genotypes were carried out using LSD at 5% probability levels.

The phenotypic and genotypic coefficient of variation as well as broad sense heritability will be estimated as described by Chaudhrary (2001) and Hallauer *et al*., (1988) as follows:

The genotypic coefficients of variation will be estimated using the formula described by Singh and Chaudhary (1985).

GCV= x 100, Where; GCV= genotypic coefficient of variation, σ_g^2 =estimate of genetic variance, $\overline{X}$ = grand mean of the respective character.

Phenotypic coefficient of variation

PCV= $\frac{\sqrt{\sigma_P^2}}{\bar{x}}$ x 100, Where; PCV= Phenotypic coefficient of variation, c =estimate of genetic variance, $\overline{X}$ = grand mean of the respective character. Using the formula adopted by Allard 26.

$$H_b^2 = \frac{\sigma^2{}_g}{\sigma_p^2} \times 100$$

RESULTS AND DISCUSSION

The results of Analysis of variance (ANOVA) for genetic variability of bread wheat evaluated in Hadejia during 2019/2020 and 2021/2021 irrigated seasons is presented in Table 1 and 2. The results revealed significant ($p \leq 0.05$) difference among genotypes for days to heading, plant height, grain yield per plot and grain yield per hectare in both years. However, significant (($p \leq 0.01$) difference observed for days to heading only for 2019. Furthermore, interaction between genotypes and year revealed significant ($p \leq 0.01$) difference for all traits investigated, except for days to maturity. This study, indicates the existence of variation and possibility of selection for heat tolerance.

Findings by Cheema, *et al.*, 2006, reported significant differences among genotypes for number of productive tillers/plant, spike length, number of spikelets/spike, number of grains/spike, 1000-grain weight and grain yield/plant. In fact the development of any plant breeding programme is dependent upon the existence of genetic variability.

Table 1: Analysis of Variance on Genetic variability of Wheat (*Triticum aestivum* L.) to heat stress at Hadejia for 2019 and 2020 dry season

		DHH		DMA		PHT		GYD		YLD/ha	
SOV	Df	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Rep	2	46.21	61.73	107.49	13.36	17.71	17.32	31.62	18.75	0.16	0.35
Gen	10	98.89**	83.19	38.02	35.89*	201.16*	340.52*	163.2*	82.46**	2.96**	1.63**
Error	20	24.35	52.46	22.95	7.59	31.55	16.42	19.61	8.58	0.25	0.29

Table 2: Analysis of Variance on Genetic variability of Wheat (*Triticum aestivum* L.) to Genotype by year interaction to heat stress at Hadejia for 2019 and 2020 dry season

Source of Variation	Df	DHH	DMA	PHT	GYD	YLD
Replication	2	162.61	113.92	13.32	36.43	0.48
Genotypes	20	33.40	0.24	382.93**	128.09**	3.84**
Genotype X Year	10	148.68**	12.21	158.75**	117.66**	0.75**
Error	42	53.49	20.16	23.88	14.23	0.26

****:** significantly different at (P≤0.05) and (P≤0.01) level of probability, DHH= days to heading, DMA= days to maturity, PHT= plant height, GYD= yield per plot, YLD/ha= grain yield per hectare, SOV= source of variation, Rep=replication, Gen=genotype

Partitioning of variance components and estimate of mean performance evaluated under dry condition at Hadejia is presented in Table 3. Phenotypic coefficient of variation (PCV) were generally higher than Genotypic coefficient variation (GCV) for all traits studied, the range of PCV to GCV was wider for all studied traits, indicating that apparent variation for these traits may not only be due to genotypes but also due to the influence of environment and selection through pure line or single seed descent may be misleading for such traits. This is in accord with those obtained by Gupta and Verma (2000); Wannan *et al.*, (2015) and Shakoor *et al*. (2007) all reported higher value of PCV to GCV in wheat indicating the role of environment in the expression of these traits. Similarly, heritability estimates were higher (>50%) for all traits except for grain yield which depicted low (<50%) value of heritability. The higher estimate of heritability observed indicates that the variation in these traits comes from genetic differences with little contribution from environmental factors. Similar results were also found by Liu and Ma, 1994; Deswal et al., 1996; Yadav et al., 2003; Ansari et al., 2004 and Gupta et al., 2004.

Table 3: Components of variance and Heritability (H_b) of the studied traits Combined.

Traits	σ_g^2	σ_y^2	σ_{gy}^2	σ_p^2	GCV (%)	PCV (%)	H_b (%)
Days to heading	19.21	23.49	31.73	28.00	31.69	46.19	68.61
Days to maturity	8.25	20.16	2.65	15.38	8.56	15.95	53.63
Plant height (cm)	17.36	23.88	44.96	26.19	23.56	35.54	66.29
Grain yield per plot (kg)	11.74	14.23	34.48	17.07	45.52	66.19	68.77
Grain yield (t/ha)	0.52	3.26	0.16	1.63	16.67	52.33	31.85

Legend: σ_g^2 = Genotypic variance, σ_p^2 = Phenotypic variance, GCV= Genotypic Coefficient of Variation, PCV= Phenotypic Coefficient of Variation, h_n = Narrow-sense Heritability

Estimated mean performance for the studied traits in 2019 and 2020 are presented in Tables 4 and 5. The results indicated that genotypes (29988 and 29823) headed earlier (52 and 53) in 2019 dry sesason, while genotype (Tesfa) recorded the highest (72.33) number of days to flower. However, different trend was observed in 2020, the results indicated that genotypes (Tesfa and 30098) headed earlier (54) days to flower, while genotypes (29988) recorded the highest (71.33) days to flower. Furthermore, genotype (29821) matured earlier (92.676 and 92.33) days in 2019 and 2020 respectively, while Norman and Tesfa are late maturing genotype for 2019 and 2020 respectively. More so, Norman was the tallest genotype for 2019, while genotype (29526) was the tallest in 2020. However, genotype (29988) was the shortest in 2019, while genotype (29642) was the shortest in 2020. Mean performance for grain yield indicated that genotype (29526) was the best yielder in 2019, in contrast to observed performance in 2020, genotype (29642) which recorded the highest yield in 2020.

Table 4: Mean Performance of Genotype evaluated at Hadejia in 2019/2020

	DHH		DMA		PHT		GYD		YLD/ha	
Genotype	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
29872	60.67	58	99.33	98.67	65.68	65.58	15.67	17.33	1.72	1.76
29823	53.33	57.67	99	95.33	82.43	83.20	23.33	20.67	2.57	3.39
29541	61.67	57	98.33	94.33	73.44	66.13	28.33	25.67	3.11	2.82
29642	61.33	60.33	93.66	91.67	83.14	60	34.33	16.33	4.27	4.77
30098	67	54	100	100.67	68.50	64.50	34.27	23.13	3.07	2.79
29988	52.3	71.33	96.67	95.67	64.77	63.80	18.33	28.67	1.68	2.78
29526	62.33	56.33	90	93.33	84.64	90.80	39.67	20.67	4.95	3.46
Tesfa	72.33	53.67	98	102.55	73.14	72.40	30.67	23.67	3.71	3.05
30119	65.67	60.33	93	96.67	82.04	85.71	23.33	25.33	2.57	2.59
29821	62	66	92.67	92.33	74.87	63.33	33.67	35	3.37	3.33
Norman	58	62.33	100.67	99	88.83	64	27.33	22	3.49	3.34
S.E	4.22	4.22	2.59	2.59	2.85	2.82		2.18	0.29	0.29

DHH= days to heading, DMA= days to maturity, PHT= plant height, GYD= yield per plot, YLD/ha= grain yield per hectare, S.E= standard error.

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MANAGEMENT OF KITCHEN WASTE MATERIAL THROUGH THE USE OF BLACK SOLDIER FLY LARVAE (*HERMETIA ILLUCENS*) FOR SUSTAINABLE WASTE MANAGEMENT AND AVAILABILITY OF FEED FOR LIVESTOCK

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ABSTRACT

Using black soldier fly larvae (BSFL) in managing and treatment of biodegradable waste such as kitchen waste is a promising and sustainable way to manage organic waste generated from our home, schools, farm, and industries. At the time of feeding on this waste, the black soldier fly larvae are growing and increasing in its biomass which will serve as feed for livestock such as poultry and fish. Total of 50 larvae weighing 0.10g of 10 days old was inoculated into a plastic of dimension and was fed with kitchen waste (substrate) of 50 g. The number of Black soldier fly larvae dropped from 50 to 37 with weight of 1.3 g while the substrate (50 g) decreased to 18.32g (frass). The proximate and chemical composition analysis results recorded are moisture content 71%, ash content 2.32%, crude protein 18.40%, crude fibre 1.34%, crude fat 2.28% and carbohydrate 4.2%. Among the minerals, calcium had 476.30mg/100g, phosphorus 126.30mg/100g, Potassium 545.80 mg/100g, sodium 65.40 mg/100g, magnesium 124.60mg/100g, iron 5.75 mg/100g, zinc 4.60 mg/100g, copper 0.16 mg/100g, and manganese 0.12 mg/100g respectively. For the vitamins, vitamin B1 had 0.19mg/100g, vitamin B2 1.60mg/100g and vitamin E 1.10mg/100g respectively. The results obtained while feeding the larvae indicated that BSFL has the potential of reducing organic waste to frass which can serve as a biofertilizer. Most of the values of the proximate and chemical composition are related to others found in BSFL fed with other substrates and they fall under the nutrient requirements of most livestock feeds. The proximate, minerals and vitamins composition of BSFL under investigation suggests that BSFL fed with kitchen waste will be a potential and promising feed source for livestock industry.

INTRODUCTION

The black soldier fly (BSF), *Hermetia illucens*, is a valuable insect species whose larvae have many potentials for converting organic waste into compost, and the larvae biomass generated could also be harvested for its protein and fatty acid content Banks *et al*. (2014). The larva feeding behavior also discourages clustering of pest flies (Pest control). The waste generated becomes useful as fertilizer (bio-fertilizer). The residue from black soldier fly larvae (BSFL) decomposition is similar to compost, contains nutrients and organic matter and, when used in agriculture, helps to reduce soil depletion. Solutions of waste disposal are being sought, and some of those proposed (already in practice) are to use the waste palm kernel shells and palm press as biofuel to create steam used in the oil palm mill processes, or the creation of mulch from empty fruit bunches and ash to be reused as fertilizer, both of which lead to self-sufficiency, sustainability and improved net energy balance of the oil palm mills (Abdullah and Sulaiman, 2013, Kamahara *et al*., 2010). According to Ebenebe (2021), Nigeria generates 542.5 million tons of organic waste per annum, and waste is fast becoming a menace in many urban centres. Black soldier fly larvae (BSFL) have large and powerful chewing mouthparts allowing them to shred and devour waste. Kitchen waste is any kind of rubbish produced during your commercial kitchen activities – such as preparing food, cleaning plates and equipment, and dealing with customers' leftovers. Food waste is the main type of kitchen waste, but other products and materials also make up such waste, including packaging, equipment, and more. The study is chosen considering the fact that management of kitchen waste is of great importance from the point of view of a healthy quality of environment. The objective of the study was to evaluate the feasibility of black soldier fly larvae to digest and degrade waste and the utilization of the BSFL as animal feed.

MATERIALS AND METHODS

Collection of material

Kitchen waste material was collected from houses, then sun dried and ground into powder form. This grinded waste material was subjected to aerobic composting to initiate microbial activity. Moisture content was maintained to 60% to 70% and the mixture was kept in a plastic container covered with paper having holes to facilitate aeration in order to get final composted material. The mixture was hand manipulated at regular time intervals and remoistened for sufficient microbial activity.

Collection and Introduction of BSFL

When the temperature became constant and the color of the kitchen waste turned brown to black, it was used as a substrate for feeding BSFL. BSFL was obtained from Entomology division NIFOR. 50 larvae of 10 days old were introduced in a small plastic containers containing about 50 g of substrate.

During the course of investigation, samples was examined at every 48 hours for 21 days of composting

Data collection

Data was collected on initial weight of substrate (g), initial number of BSFL, number of BSFL after, initial weight of BSFL (g), weight of BSFL after (g), and weight if substrate after

Proximate and Chemical Composition Analysis

The BSFL that was reared to pre-pupae with the substrate (kitchen waste) was collected at the end of the experiment and was analyzed for its proximate and chemical composition following the method of AOAC (2010).

RESULTS AND DISCUSSION

Larvae management and composting on BSFL


Plate 1. 0-1 hour of introduction of BSFL.   Plate 2. 24 hours of introducing BSFL

‘


Plate 3. 240 hours of introduction of BSFL.   Plate 4. S400 hours of introduction of BSF

Table 1. Impact of composting on BSFL

Initial weight of substrate (g)	Initial weight of larvae (g)	Initial number of larvae	Final weight of substrate (g)	Final weight of larvae (g)	Final number of larvae
50.00	0.10	50	18.32	1.30	37

As shown on table 1. Substrate weighing 50g was degraded or reduced to 18.32g by the BSFL. The number of BSFL introduced during the experiment reduced to 37 from 50, while the weight of the BSFL increased to 1.30g from initial weight of 0.10g within 21 days of the experiment.

Table 2. Proximate analysis of BSFL fed with kitchen waste for 21 days

S/N	Parameters	BSFL	Units
1	Moisture content	71.30	g/100g
2	Ash content	2.32	g/100g
3	Crude fibre	1.34	g/100g
4	Crude fat	2.28	g/100g
5	Crude Protein	18.40	g/100g
6	Carbohydrate	4.20	g/100g

Table 3. Mineral contents of BSFL fed with Kitchen waste for 21 days

S/N	Minerals	BSFL	Units
1	Potassium (K)	545.80	Mg/100g
2	Sodium (Na)	65.40	Mg/100g
3	Calcium (Ca)	476.30	Mg/100g
4	Magnesium (Mg)	124.60	Mg/100g
5	Phorsphours (P)	126.30	Mg/100g
6	Nitrogen (N)	2.94	Mg/100g
7	Manganese (Mn)	0.12	Mg/100g
8	Iron (Fe)	5.75	Mg/100g
9	Zinc (Zn)	4.60	Mg/100g
9	Copper (Cu)	0.16	Mg/100g

Table 4: Vitamin content of BSFL fed with kitchen waste for 21days

S/N	Vitamins	BSFL	Units
1	B1	0.19	Mg/100g
2	B2	0.60	Mg/100g
3	E	1.01	Mg/100g

The experiment affirmed that black soldier fly larvae have potential to convert organic waste into high value product (bio-fertilizer) and in return the organic waste such as kitchen waste will increase the biomass of the black soldier fly larvae. The larvae possessed the ability to valorized organic waste (kitchen waste) which is a potential benefit for developing countries like Nigeria. This conforms to the work of Nana *et al.* (2018).

The results of the proximate and chemical composition of BSFL in this study is a confirmation of its utilization as an ingredient for animal feeds which has gained considerable interest recently. This observation is similar with the reports of Nyakeri *et al.* (2017), who reported the crude protein, crude fibre, ash content, and fats of wild black soldier fly larvae. He further stated the mineral and vitamin content of wild black soldier fly larvae, which is similar with the findings of this study.

CONCLUSION

The work indicated the possibilities in recycling organic waste such as kitchen materials by using this waste to feed the BSFL. By doing so the BSFL builds its body composition of protein, fat, mineral and other vital nutrients required for feed production. This system could be a sustainable method of organic waste management and a way to provide the livestock industry with nutrients for livestock farming especially now that the cost of grains and soyabean are on the very high side.

However, there is a need to always examine the nutrient content or composition of these waste materials as the quality of substrates may probably influence or determine the growth, nutrient and biomass of the black soldier fly larvae.

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EVALUATION OF SORGHUM (*SORGHUM BICOLOR* (L.) MOENCH) GENOTYPES FOR GRAIN AND OTHER YIELD TRAITS IN SAVANNAS AND DERIVED SAVANNA OF NIGERIA

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ABSTRACT
Sorghum [Sorghum bicolor (L.) Moench] is the fifth most important cereal crop in the world, and is one of the most widely cultivated cereal in Nigeria. Traditionally, it is grown extensively from the Southern Guinea to the Sahel Savannah of Nigeria, primarily because of its adaptation to varying ecological conditions. The industrial demand for sorghum has grown with several flour mills in the country using it or considering it as a substitute/compliment to wheat. There is also increasing demand for it by malting industries for beverages. These will significantly increase the demand for sorghum in the coming years. The aim of the study was to evaluate the yield stability of selected varieties across the different agro-ecological zones of Nigeria. Ten sorghum genotypes were planted in 7 locations covering the Sahel, Sudan, Northern Guinea, Southern Guinea and derived Savannas agroecological zones in a Randomised Complete Block Design. Eight of these genotypes have been officially released in Nigeria, while two are advanced sorghum lines from ICRISAT germplasm. Analysis of variance for the Additive Main Effect and Multiplicative Interaction (AMMI) model showed significant differences amongst genotypes, environments and interactions between genotypes and environments (P>0.001) for grain yield, genotypes, environments and interactions accounted for 25.5, 48.2 and 5.0% of the sum of squares respectively. This indicated serious contribution of environment in the performance of the genotypes. The study demonstrated that several of the selected sorghum genotypes are adapted to the different locations. These differences can be exploited for cultivation in different agro-ecological zones or at different planting dates in a similar zone.

INTRODUCTION
Sorghum [*Sorghum bicolor* (L.) *Moench*] is the fifth most important cereal crop in the world, and is one of the most widely cultivated cereal in Nigeria. Traditionally, it has been grown extensively from the Southern Guinea to the Sahel Savannah of Nigeria, primarily because of its adaptation to drought. The demand for sorghum has grown appreciably and is expected to increase significantly in the coming years for direct consumption, and industrial demand by flour mills who use it as a substitute/complement to wheatby malting industries for beverages, as well as by livestock feed companies. Although sorghum is an indigenous crop and exceptionally adapted to the region, the yields on farmers' fields are on average low, generally less than 1.5 t/ha despite the potential yields of above 3 tons per hectare (Ajeigbe *et al*., 2018), this is caused mainly by low inputs, poor soil fertility, and the non-availability/low-adoption of improved genotypes or hybrids with significant yield superiority over farmers' landraces. Exploitation of genetic variability is the most important tool in plant breeding, and this has to be inferred by phenotypic expression. The consequences of the phenotypic variation depend largely on the environment. This variation is further complicated by the fact that not all genotypes react in similar ways to the change in environment. If relative performance of genotypes is different in different environments, then Genotype by environment (G × E) interaction becomes a major challenge to crop improvement. G x E interaction is the variation, arising from the lack of correspondence between the genetic and non-genetic effects in multi-location trials. Interactions may involve change in rank order for genotypes between environments and change in the absolute and relative magnitude of the genetic, environmental and phenotypic variances between environments Teressa *et al* (2019). Different statistical models are being used to quantify the genotype by environment interactions including the classical analysis of variance (ANOVA), stability and multivariate analysis. The

additive, multiplicative interaction component (AMMI) model is a hybrid analysis that incorporates both the additive and multiplicative components of the two-way data structure. In this model the additive portion is separated from interaction by analysis of variance (ANOVA) and the multiplicative component is further decomposed by interaction principal component Zobel *et al* (1988). The aim was to evaluate the yield stability of selected sorghum varieties across different agro-ecological zones of Nigeria and identify high yielding, high biomass and stable sorghum genotypes. Therefore, the combined data was also analyzed using AMMI model that further partitions GEI into interaction principal component axis (IPCA) components. Hence, the AMMI model analysis had partitioned the GEI into the first two significant IPCAs. AMMI ANOVA given in Figure 1.

MATERIALS AND METHODS

The study comprised of 10 sorghum genotypes (SAMSORG 42, SAMSORG 45, SAMSORG 47, SAMSORG 48, CSR 01, CSR 02, CSR 03H, CSR 04H, 12KNICSV 418 and Framida) planted in 7 locations (Gambawa, Minjibir, BUK, Zaria, Makurdi, Ilorin, Iseyin) covering the Sahel, Sudan, Northern Guinea, Southern Guinea and derived Savannas agroecological zones of Nigeria. Eight of these genotypes have been officially released in Nigeria, while two are advanced sorghum lines from ICRISAT germplasm. The genotypes were selected to cover different maturity groups and ensure high food and malting quality. Land preparation was carried out by tractor (harrowed and ridged) in Minjibir, BUK, Zaria and Makurdi. At Ilorin and Iseyin trial sites were ploughed and manually ridged while by animal drawn ridger in Gambawa. Planting was done from 22 June – 23 July 2021 and from 23 June to 22 July in 2020. Animal manure was applied at the rate of 2 t/ha after harrowing before ridging in Minjibir and at planting in other locations. NPK (15:15:15) was applied at the rate of 150 kg/ha at planting and 100 kg urea was applied at 3-5 weeks after planting (WAP). The experiments were laid out in a Randomized Complete Block Design (RCBD) with four replications at each location. Each plot was made up of 4 rows, each 5 m long. Row-to row spacing was 75 cm and hill to hill spacing was 30 cm. Seeds (4-6) were sown per hole at a depth of 3-5 cm and thinned to 2 plants per hill at 2 WAP. Weeding was done manually. All the agronomic management practices (thinning, weeding, fertilizer application, pesticide spraying, harvesting, etc.) were applied accordingly. Data on weather (rainfall, minimum, maximum temperatures and humidity) was collected from the nearest weather stations. Days to 50% flowering, days to 80% plant maturity, plant height, grain and stalk yield from two middle rows were collected at harvest and extrapolated to grain and stalk yields. The data was analysed using Genstat statistical software (19th Edition).

RESULTS AND DISCUSSION

Combined analysis of variance (ANOVA) across locations for year, location, grain yield, revealed highly significant variability among the genotypes with significant environment, and genotype by environment interaction effect (Table 1). Significant differences were observed among the genotypes for days to 50% flowering while the mean values for the different genotypes ranged from 69 to 93 days. Genotype FRAMIDA was the earliest to flower (69 days) and followed by CSR 04H (78 days). SAMSORG 47 and CSR 02 had the longest period for flowering (93 days). The genotypes differed significantly in plant height, ranging from 147.0cm to 352.4cm. The highest plant height was recorded in CSR 02 (352.4cm) and CSR 01 (352.2cm). The shortest of 147.0cm was in 12KNICSV 418. Days to maturity ranged from 103 to 128 days with a mean of 118 days, FRAMIDA (103 days) were early maturing and SAMSORG 47 matured last at 128 days, while in Iseyin, genotype FRAMIDA (84 days) is the earlier maturing and SAMSORG 47 (128 days) matured last.

Mean grain yields differ significantly between genotypes in all the locations (Table 2). The lowest grain yield (1447 kg/ha) was obtained in CSR 03H and highest of 2510 kg/ha in CSR 02. Significantly higher mean grain yields were recorded also in CSR 01 (2479 kg/ha), SAMSORG 45 (2285 kg/ha), SAMSOR 42 (2284 kg/ha) and 12KNICSV 418 (2205 kg/ha) higher than the overall mean of the 10 genotypes. Genotypes CSR 03H (1447 kg/ha), FRAMIDA (1827 kg/ha) and CSR 04H (1903 kg/ha) had significantly lower grain yields compared to the grand mean (2113 kg/ha) (Table 3). Stalk yield shows significant different among the genotypes, SAMSORG 42, CSR 01, CSR 02 and SAMSORG 47 recorded the highest stalk yields of 10,230 kg/ha, 9,878 kg/ha, 9,660 kg/ha and 8,443 kg/ha respectively. The earlier maturing genotypes produce less biomass (Table 2) compared to medium maturing genotypes; FRAMIDA (5,317 kg/ha), CSR 03H (5,488 kg/ha) and 12KNICSV 418 (5,510 kg/ha). The Additive Main Effect and Multiplicative Interaction (AMMI) model showed significant differences amongst genotypes, environments and interactions between genotypes and environments ($P>0.001$) (Table 1) for grain yield, genotypes, environments and interactions accounted for 25.5, 48.2 and 5.0% of the sum of squares respectively. This indicated serious contribution of environment in the performance of the genotypes. *The study demonstrated that several of the selected sorghum genotypes are adapted to the different locations. Based on the* AMMI and GGE plot (figure 1), SAMSORG 48, SAMSORG 45, CSR 01, CSR 02 and 12KNICSV 418 are found to be adapted to Ilorin, Gambawa, Iseyin, BUK and Makurdi respectively. Zaria has 2 adapted varieties, SAMSORG 42 and SAMSORG 47. SAMSORG 47 has also found to be good in Ilorin and Makurdi. SAMSORG 45 has found to also be adapted in Minjibir and BUK. In the sudano-Sahelian areas of Gambawa, Minjibir and BUK, SAMSORG 45 is recommended; while SAMSORG 42 and SAMSORG 47 are recommended for northern guinea such as Zaria and Makurdi environs. SAMSORG 47 and SAMSORG 48 are recommended for Ilorin and CSR 01 for Iseyin in the southern guinea and derived savannahs respectively. The high mean square values for locations across the test environments indicating that the test genotypes responded differently across environments. Hence, decision on selecting genotypes need to consider the target environments. Similar findings have been reported by Adugna (2007) and Gasura *et al*., (2015) on multi-environment evaluation of sorghum genotypes. Combined ANOVA determines if GEI is a significant source of variation or not and estimates it but does not provide insight into the patterns of genotypes or environments that give rise to the interaction Samonte *et al*., (2005). The different response of genotypes across the testing environment is considered as a hindrance in selecting and recommending of crops and cause yield fluctuation (Yan and Tinker, 2006).

Table 1. Stability components of grain yield for sorghum genotypes from fourteen environments of Nigeria

Source	d.f.	S.S.	M.S.	Explained %
Genotypes	9	11522597***	1280289	25.5
Environments	13	31471030***	2420848	48.2
Interactions	115	28866233***	251011	5.0
IPCA 1	21	11601718***	552463	11.0
IPCA 2	19	7378812***	388359	7.7
Residuals	75	9885703	131809	

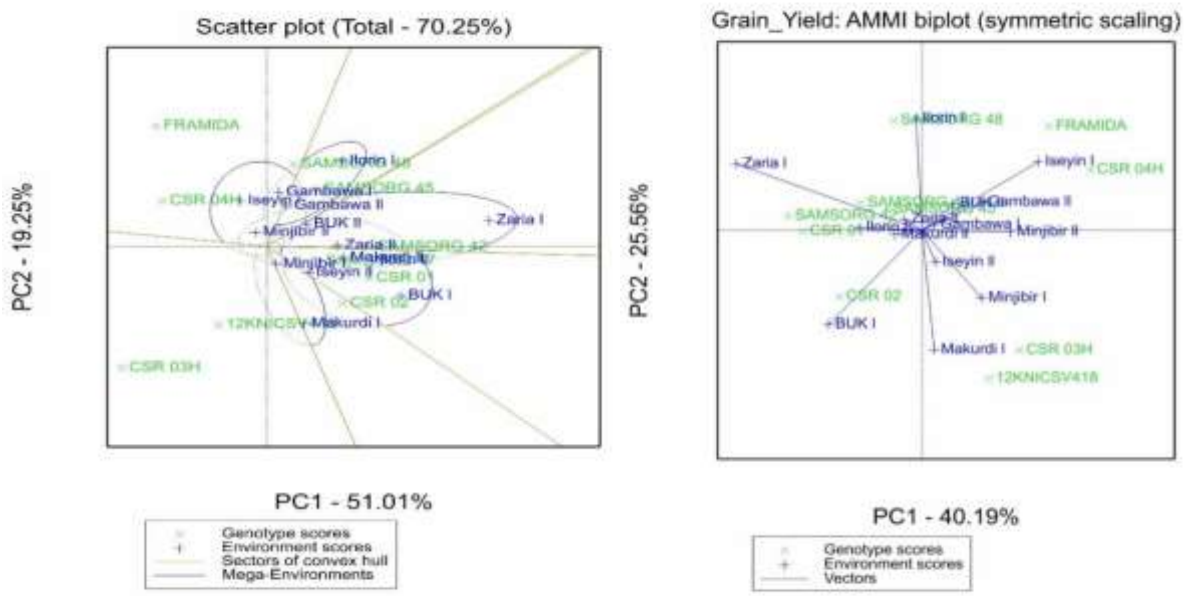

Figure 1. GGE and AMMI Biplot for grain yield of sorghum genotypes grown in seven locations for two years

Table 2: Days to 80% Maturity of Sorghum Genotypes Evaluated in all Location

Variety/Location	Gambawa	Minjibir	BUK	Zaria	Makurdi	Ilorin	Iseyin	Mean
12KNICSV418	125	124	128	117	118	108	110	118
CSR 01	121	122	138	122	122	115	121	123
CSR 02	123	124	137	125	125	117	123	125
CSR 03H	124	114	114	107	108	101	101	110
CSR 04H	115	112	114	103	103	99	102	107
FRAMIDA	112	112	114	97	97	95	95	103
SAMSORG 42	120	125	138	127	127	118	123	125
SAMSORG 45	119	121	121	111	107	102	107	112
SAMSORG 47	128	124	138	128	128	124	128	128
SAMSORG 48	121	125	127	123	123	121	121	123
F pr.	***	***	***	***	***	***	***	
Grand mean	122.5	122	127	116	116	110	113	118

SED	0.811	1.489	2	1.995	1.888	1.934	2.265
LSD	1.657	3.056	4.200	4.094	3.874	3.967	4.648
CV%	0.9	1.7	0.2	2.6	2.4	2.6	2.9

Table 3: Grain Yield (kg/ha) of Sorghum Genotypes Evaluated in all Location

Variety/Location	Gambawa	Minjibir	BUK	Zaria	Makurdi	Ilorin	Iseyin	Mean
12KNICSV418	2715	2633	2287	1525	2437	2009	1828	2205
CSR 01	1866	1727	2899	3000	2715	3096	2051	2479
CSR 02	2381	1619	2579	2742	3299	2823	2128	2510
CSR 03H	884	1336	1330	993	2166	1741	1683	1447
CSR 04H	1639	1619	1572	1463	2176	2388	2469	1903
FRAMIDA	2007	1638	1609	1340	1542	2606	2051	1827
SAMSORG 42	1892	1366	2178	2918	2801	3215	1619	2284
SAMSORG 45	2636	1829	2503	2381	2108	2823	1719	2285
SAMSORG 47	1267	1594	2114	2444	2519	2847	2538	2189
SAMSORG 48	2108	2241	1881	2270	1817	3054	1581	2136
F pr.	***	***	***	***	***	***	***	
Grand mean	1846	1760	2095	2107	2358	2660	1967	2113
SED	51.6	163.9	130.6	78.8	87.2	67.5	154.5	
LSD	105.5	336.3	267.9	161.8	179.0	138.6	316.9	
CV%	3.9	10	9	7.4	4.8	4.2	8.6	

CONCLUSION

Combined analysis of variance displayed highly significant G x E interaction and variations were significant among the test sites. Selecting genotypes in diversified testing locations and assessing yield stability of sorghum genotypes is quite vital. The AMMI analysis for the additive main effect and multiplicative interaction effect revealed significant difference for genotypes, testing locations and genotype by testing location interaction. The values of the different genotypes for days to 50% flowering and physiological maturity showed significantly different. These differences can be exploited for cultivation in different agro-ecological zones or at different planting dates in a similar zone.

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SCREENING DIFFERENT CHEMOTHERAPEUTIC AGENTS FOR EFFECTIVE ELIMINATION OF MICROBIAL CONTAMINATION IN CASSAVA TISSUE CULTURE

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ABSTRACT

Microbial contamination is a major cause of economic losses in commercial and research plant tissue culture operations. In this study, different chemotherapeutic agents were screened to effectively eliminate both fungal and bacterial contaminants during the in vitro establishment of two selected cassava cultivars (Manihot esculenta Crantz) namely Umucass 36 and Umucass 45, in National Root Crops Research Institute (NRCRI), Umudike Tissue culture/Genetic Transformation laboratory. Chemotherapeutic agents used for the experiment in single and combined treatment in an agar-embedded system were: Antibacterials comprising Ampicillin and Kanamycin at 100mg/L concentration; Fungicides comprising Starinsec® (Imidacloprid 40% + Mancozeb 40%), Nystatin (Phytotech) and Imidazole (Phytotech) at 100mg/L concentration and Plant Protective Mixture™ (PPM) at 2ml/L used as a control. The explants of the cassava cultivars were aseptically established in culture and the results showed that Ampicillin and a combination of Nystatin/Ampicillin compared favorably with PPM in contamination control but outperformed it in the leaf/root proliferation for Umucass 36. On the other hand, PPM and Nystatin/kanamycin treatments gave the best contamination control result for Umucass 45, although other combinations of chemotherapeutic agents showed potentials in being effective in terms of other important traits. The study has provided an alternative effective protocol for establishing clean in vitro cultures of the select cultivars while recommending further research to evaluate possible effect on the genetic fidelity of the varieties.

INTRODUCTION

Microbial contamination is one of the major challenges hampering the application of *in vitro* micropropagation technique (Altan *et al.*, 2010) which could be as a result of explant-borne pathogen or as a laboratory contamination. Various efforts have been made to get rid of microbial contaminants in plant tissue culture (Medjemem *et al.*, 2016). Although surface sterilization of the explant to get rid of epiphytic (surface-living) microorganisms is carried out frequently, there are endophytic (within the tissues) organisms which colonize inside of the living plant tissue and cause contamination of tissue cultures (Cassells, 2012).
A wide range of microorganisms (filamentous fungi, yeasts, bacteria, viruses and viroids) and micro-arthropods (mites and thrips) have been identified as contaminants in plant tissue cultures. Contamination of plant tissue culture by different microorganisms such as bacteria and fungi reduces tissue productivity and results in variable growth, tissue necrosis, reduced shoot proliferation, reduced rooting among other negative effects (Altan *et al.*, 2010).
Several different methods are used to eliminate fungal and bacterial contamination, including the use of antibiotics and fungicides, as well as inactivation by heat and light (Sen *et al.*, 2013). However, these methods can also be injurious to the *in vitro* tissue if not safely applied.
The use of chemotherapeutic agents such as antibiotics in plant tissue culture has been widely reported. Mbah and Wakil (2012) reported that antibiotics used in plant tissue culture should be soluble, stable, unaffected by the components or pH of the medium, lack side effects, broadly active, non-resistance inducing, inexpensive and non-toxic to humans. In other instances, antibiotics effective on isolated organisms cannot be used for treating contaminated plants due to phytotoxicity or poor penetration into tissues (Singh *et al.*, 2020). Although phytotoxicity and development of antibiotic-resistant bacterial populations have restricted the use of antibiotics,

these side effects can be taken care of by the use of combinations of antibiotics at relatively lower concentrations (Yang *et al.*, 2021).

This present study was focused on screening and determining chemotherapeutic agents with the most effective activity against microbial contaminants *in vitro* and evaluating the effect of the chemotherapeutic agents on the growth parameters of the selected cassava cultivars.

MATERIALS AND METHODS

The study was carried out in the National Root Crops Research Institute (NRCRI), Umudike Tissue culture/Genetic Transformation laboratory, Umudike Abia State, Nigeria.

Two pro-vitamin A cassava cultivars (Umucass 36 and Umucass 45) were selected for this study due to the persistent microbial contamination incidence associated with their *in vitro* establishment and importance to genetic transformation activities. The planting materials were obtained from the experimental farm at National Root Crops Research institute at three months after planting (3MAP) and established *in vitro* culture.MS medium (1962) was prepared (Murashige and Skoog, 1962) using 3% sucrose (w/v) and 0.8% (w/v) agar) in 250ml capacity glass jar. Chemotherapeutics used for the experiment were: Antibiotics- Ampicillin and Kanamycin (Phytotech, USA) at 100mg/L concentration; Fungicides- Starinsec® (Imidacloprid 40% + Mancozeb 40%), Nystatin (Phytotech), Imidazole (Phytotech) at 100mg/L concentration. Plant Protective Mixture™ (PPM) at 2ml/L was used as a positive control and zero additive (NONE) for negative control.

Surface sterilized nodal explants were initiated into 50ml MS medium primed with the chemotherapeutics in single and combined forms as denoted below:

T1= Starinsec; T2= Nystatin; T3= Imidazole; T4=Ampicillin; T5= Kanamycin; T6= Starinsec/Ampicillin; T7= Starinsec/Kanamycin; T8= Nystatin/Ampicillin; T9= Nystatin/Kanamycin;T10=Starinsec/Ampicillin/Kanamycin; T11=Nystatin/Ampicillin/Kanamycin; T12=PPM; T13= None (zero additive).

Surface sterilization was carried out aseptically using the following sterilants; 10% sodium hypochlorite, 70% ethanol and 20% (w/v) benomyl fungicide. The labelled culture bottles were sealed and incubated at a temperature of 26 ± 2ºC for 16 hour photoperiod and 8 h darkness at light intensity of 2000-3000 lux in the growth chamber.

Cultures were observed weekly (for a 4-6week cycle) for visual signs of microbial contamination and data on growth parameters (number of leaves, roots, vigour) were collected at 4weeks. Each experimental unit was replicated three times in a completely randomized design (CRD) and the experiment was repeated twice. The means of data collected were subjected to analysis of variance (ANOVA) at 0.05% level of significance using R-Software and descriptive statistics.

RESULTS AND DISCUSSION

A summary of treatment means showing the effect on number of leaves, roots and vigour of Umucass 36 and Umucass 45 are highlighted in **Table 1.** The treatment effect on contamination (**Figure 1**) showed that Ampicillin (T4), Starinsec/Ampicillin (T6), Starinsec/Kanamycin (T7), Nystatin/Ampicillin (T8) were comparable with the positive control [PPM] in their performance for Umucass 36 at 100% contamination control; while Nystatin/Kanamycin (T9) compared with the positive control at 100% for Umucass 45. Fang and Hsu (2012) reported that aminoglycosides antibiotics such as kanamycin have been specifically found effective against *in vitro* phytopathogens as corroborated by this study.

For leaves/shoot proliferation, there was a significant effect of treatment on genotype/cultivar (**Figure 2**); Umucass 36 had the highest mean number of leaves (3) for the treatment effect with Ampicillin (T4) which agreed with Mineykina *et al.* (2020) who reported on the effectiveness of beta-lactam antibiotics (cefotaxime and ampicillin) as not only antimicrobial in their activity but also growth-enhancing in the microspore embryogenesis of *Brassia* spp. This trend was not followed by the Umucass 45 cultivar that had its highest mean number of leaves (4.0) with the negative control and Starinsec/Kanamycin (T7) as second highest (3.5).

For rooting in Umucass 36, Ampicillin (T4), Starinsec/Ampicillin (T6) and Nystatin/Ampicillin (T8) among others outperformed the positive control (PPM) which conformed with the findings of Mineykina *et al.* (2020) but was not observed for Umucass 45 which had highest rooting with PPM (**Figure 3**).

The vigour of both cultivars were significantly affected by the treatments with Ampicillin (T4) & Nystatin/Ampicillin (T8) outperforming that of the positive control (PPM) (**Figure 4**).

Comparatively for all parameters evaluated, Ampicillin (T4) and Nystatin/Ampicillin (T8) outperformed the positive control (PPM) for Umucass 36; for Umucass 45, positive control (PPM) in conformity with the findings of Leão *et al.* (2020) and Nystatin/kanamycin (T9) performed at 100% contamination control (**Figure 5)**.

CONCLUSION AND RECOMMENDATIONS

Umucass 36 and 45 are important genetic transformation candidates not just due to their high Pro Vitamin A content, also due to their high compatibility and susceptibility to the manipulation protocols. A microbial contamination elimination protocol using Ampicillin and a combination of Nystatin/Ampicillin in an agar-embedding system gave clean cultures without compromising the leaf/root proliferation of Umucass 36. Although, PPM and Nystatin/kanamycin treatments gave the best contamination control result for Umucass 45, other combinations of chemotherapeutic agents showed potentials in being effective in terms of other important traits. It was also observed that PPM^{TM} can be used for long term conservation of the select cultivars while using these cost-effective chemotherapeutic agents in their *in vitro* establishment for genetic transformation that requires growth proliferation within a short cycle of 3-4 weeks.

However, it is recommended that a further step of genetic fidelity testing is carried out on the target cultivars to investigate somaclonal variation that may be induced by the use of these agents at the investigated concentration (100mg/L). Other alternatives such as botanicals with antimicrobial properties should be tested across different cultivars of interest.

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TABLE 1: Treatment means for Umucass 36 and Umucass 45

Treatments	No. of Leaves		Vigour		No. of Roots		Contamination	
	Umucass36	Umucass45	Umucass 36	Umucass 45	Umucass 36	Umucass 45	Umucass 36	Umucass 45
T1 [STARIN]	3.33±0.7	0.67±0.7	2.67±0.3	0.33±0.3	1.67±0.9	0.67±0.7	0.33±0.3	1.00±0.0
T2 [NYSTATIN]	2.00±0.6	2.33±0.3	1.67±0.3	2.67±0.3	0.67±0.7	1.00±0.6	0.33±0.3	0.33±0.3
T3 [IMIDAZ]	2.67±0.3	1.67±0.9	1.67±0.3	2.00±1.0	2.00±0.6	0.67±0.7	0.67±0.3	0.67±0.3
T4 [AMP]	3.33±0.3*	2.00±1.0	2.67±0.3*	2.00±1.0	1.67±0.7	1.00±0.6	0.00±0.0*	0.33±0.3
T5 [KAN]	2.00±1.0	2.33±0.7	0.67±0.3	1.67±0.7	0.00±0.0	0.67±0.7	0.33±0.3	0.67±0.3
T6 [S/AMP]	1.67±0.9	1.00±1.0	1.00±0.0	1.00±1.0	3.33±0.3	0.33±0.3	0.00±0.0*	0.67±0.3
T7 [S/KAN]	2.00±0.6	2.33±1.2	1.33±0.3	1.67±0.9	0.33±0.3	1.00±1.0	0.00±0.0	0.33±0.3

T8 [NYS/AMP]	2.67±0.9*	2.67±0.3	2.00±0.6	3.00±0.0	3.00±0.6	1.33±0.9	0.00±0.0*	0.33±0.3
T9 [NYS/KAN]	1.33±0.3	2.67±0.3	1.33±0.3	3.00±0.0	0.00±0.0	0.00±0.0	0.33±0.3	0.00±0.0*
T10 [S/AMP/KAN]	2.67±0.3	2.33±0.3	2.33±0.3	2.67±0.3	0.33±0.3	0.00±0.0	0.33±0.3	0.33±0.3
T11 [NYS/AMP/KAN]	1.67±0.7	1.00±1.0	1.33±0.3	1.00±1.0	0.33±0.3	0.00±0.0	0.00±0.0	0.33±0.3
T12 [PPM]	2.00±0.0	2.00±0.0	1.33±0.3	2.33±0.3	0.67±0.7	2.67±0.3	0.00±0.0*	0.00±0.0*
T13 [NONE]	1.33±0.7	2.00±1.2	1.33±0.7	1.67±0.9	1.00±0.6	0.00±0.0	1.00±0.0	0.33±0.3

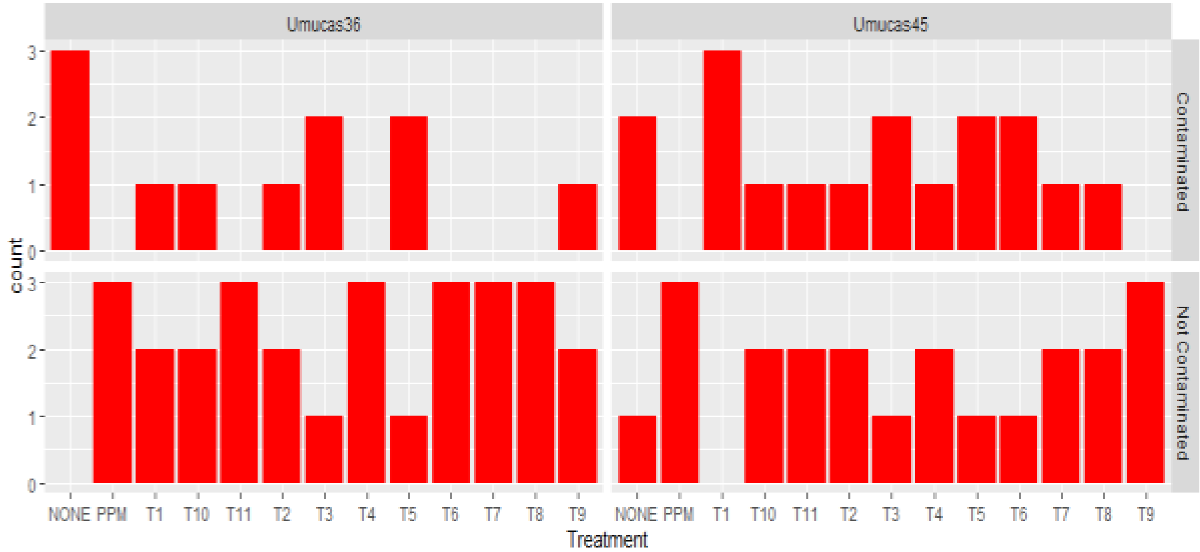
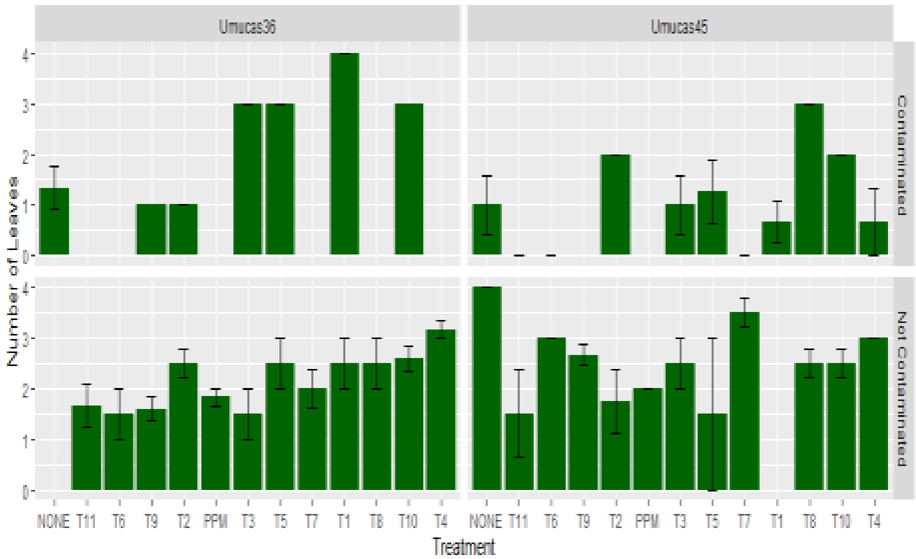


Figure 1: Treatment effect on Microbial Contamination incidence of Umucass 36 and Umucass 45 *__T1__=Starinsec; **T2**=Nystatin; **T3**=Imidazole; **T4**=Ampicillin; **T5**=Kanamycin; **T6**=Starinsec/Ampicillin; **T7**= Starinsec/Kanamycin;**T8**=Nystatin/Ampicillin;**T9**=Nystatin/Kanamycin;**T10**=Starinsec/Ampicillin/Kanamycin; **T11**=Nystatin/Ampicillin/Kanamycin; **PPM**=+VE CONTROL; **NONE**=-VE CONTR



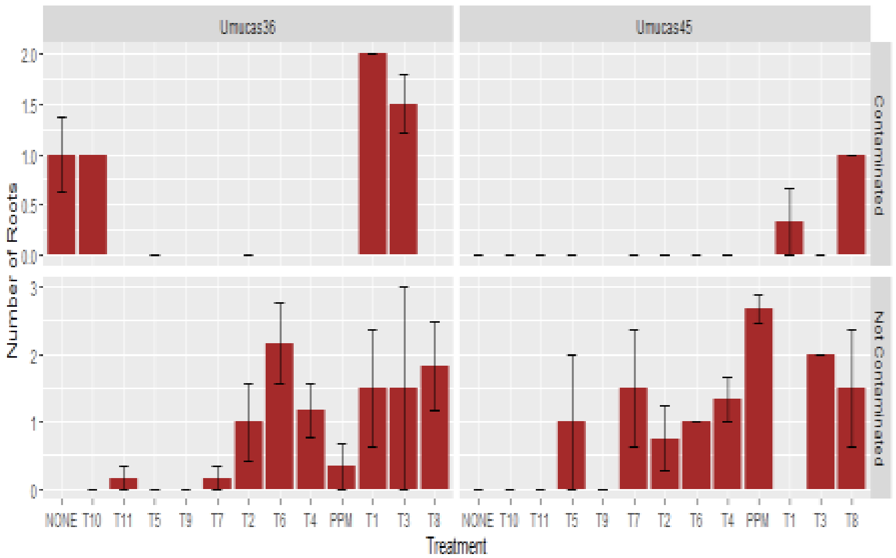


Figure 2: Treatment effect on Leaves of Umucass 36 and Umucass 45
Figure 3: Treatment effect on Roots of Umucass 36 and Umucass 45

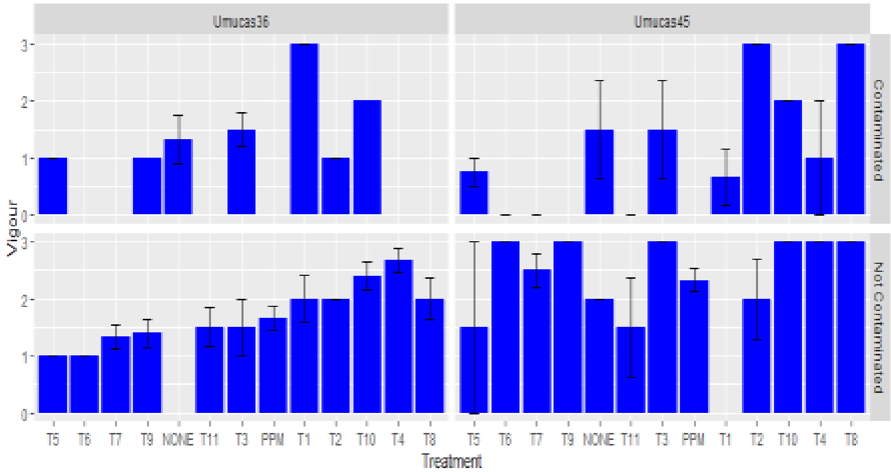


Figure 4: Treatment effect on Vigour of Umucass 36 and Umucass 45

Figure 5: Clean cultures of Umucass 36 and Umucass 45

GENETIC STUDIES OF BRIX CONTENT IN SOME SORGHUM (*SORGHUM BICOLOR* (L) MOECH) LINES IN NIGERIA

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ABSTRACT

Sweet sorghum (Sorghum bicolor (L.) Moech) is a type of cultivated sorghum and has been recognized widely as potential alternative source of bio-fuel because of its high fermentable sugar content in the stalk. A substantial variation of brix content and related traits is rarely known to exist in sweet sorghum. The objective of the studies were to estimate the extent of heritability in some cultivated genotypes of sweet sorghum. The experiment consisted of three crosses from six generation (P_1, P_2, F_1, F_2, BC_1P_1 ,BC_2P_2). Nineteen traits were evaluated on six generations during two seasons(wet and dry). The phenotypic coefficient of variation (PCV) was greater than the genotypic coefficient of variation (GCV) for most of the traits studied in all the locations indicating high environmental influence amongst all the genotypes across the locations except 264.45 of grain yield and 531.49 of panicle weight(wet) and 703.25 of grain yield, 704.30 grain yield(dry). While high broad sense heritability was recorded (98.15) for number of leaves (wet season), high narrow sense heritability(75.15) for number of leaves. However, high genetic advance was recorded in only the dry season (33.67) of brix content at milk stage, was observed across all the location indicating the selection prospects for further breeding. The PCV ranged from 5.13 for panicle weight to 264.45 of grain yield while the GCV ranged from 2.31 for fresh biomass to 91.65 of number of leaves at Bauchi. While at Zaria wet season PVC ranged from 7.81 for panicle weight to 531.49 of grain yield. GCV ranged from 1.49 for fresh juice weigth to 120.49 for number of leaves. However, at Bauchi dry season PCV varied from 7.64 of panicle weight to 703.25 of grain yield, whereas GCV varied from 2.26 of fresh volume (ml) to 54.00 of stem diameter (mm). while at Zaria dry season PVC ranged from 8.57 of panicle weight to 704.30 for grain yield, and the GCV ranged from 4.83 of leaf length to 74.66 of stem diameter. The heritability (Hbs) estimates were 2.29 for panicle weight to 98.15 for number of leaves, with GA of 33.67% for brix content at milk stage at Bauchi wet season whereas, Hns estimates varied from 1.21 for panicle weight, 58.76% of leaves length, 5.17% for days to fifty per cent heading, 94.19% for panicle weight , 0.03% for brix content at maturity to 75.43% for number of leaves with GA of 25.25% in Zaria. Based on the results of the study, it concluded that, selection for brix content should be delayed in early generations and improved using recurrent selection approach.

Keywords: *GCV, PCV, Heritability.*

INTRODUCTION

Sorghum [*Sorghum bicolor* (L.) Moench) is a tropical C4 grass noted for its versatility, wide adaptation to temperate climates Hatamipour,, & Jahanshah, 2015, and improved water-use efficiency relative to other grasses Olukoya, & Aichele, (2015). “Sweet sorghum” refers to a specific ideotype that has high biomass and juicy stems with high concentrations of sugar (Serna-Saldívar, & Heredia-Olea, 2012). Sucrose concentrations in sweet sorghum increase rapidly after flowering, and harvest is usually performed at the dough stage of grain filling, around 30 d after anthesis. Historically, sweet sorghum has been used for small-scale U.S. syrup production, but there is growing interest in its use as a bioenergy crop. In climates where sugarcane (*Saccharum officinarum* L.) is widely grown, a complementary sugarcane–sweet sorghum harvesting system could potentially extend the harvest window an additional 3 to 4 month (Ranggi *et a*l, 2016).

Sweet sorghum sugar yields are considerably lower than those of sugarcane. However, sweet sorghum is an annual diploid crop that has received relatively little breeding attention, suggesting that rapid genetic improvement may be possible. Physiological mechanisms underlying sugar accumulation in sweet sorghum are not well understood. Like sugarcane, sweet sorghum accumulates sucrose in stem parenchyma cells, but phloem loading and the timing of sucrose accumulation both appear to differ between the two species. In sugarcane, sucrose transfer in mature internodes is predominantly symplasmic, with sugars loaded into the phloem via plasmodesmata (Rutto, Xu, & Kering, 2013) , whereas in sorghum, sucrose transfer is symplasmic in growing internodes but apoplastic in mature internodes. Kalpande, & Unche,(2014) reported that sweet sorghum sugar accumulation increases rapidly after panicle emergence, once internode elongation has ceased. Other studies suggest that the timing of sucrose accumulation is similar in sweet sorghum and sugarcane, beginning while stem elongation is still occurring (Sami et al., 2013). Some of these contradictory findings might result from the use of photoperiod sensitive (PS) versus photoperiod-insensitive (PI) sorghum genotypes. In PI genotypes or PS genotypes grown under short days, internode maturation is generally coincident with flowering, whereas in PS genotypes grown under long days, flowering is delayed relative to internode maturation, and sugar levels at anthesis are considerably higher Almodares & Hadi, (2009). Overall, the data suggest that sugar accumulation is dependent on internode maturation rather than flowering, but for practical purposes sugar accumulation before flowering is limited to the lower internodes of PS genotypes grown under long days. Genetic mechanisms underlying sugar hyper accumulation in sweet sorghum are unknown. However, sugar yield and its component phenotypes, Brix and juice volume, appear to be quantitative traits in sorghum with significant environmental and genotype-by-environment effects Oyier et al., (2017). The economic superiority is contributed by characters such as stalk yield, stalk sugar content (Brix %), stalk juice extractability, content of non-reducing and reducing sugars and grain yield Li, & Dale, (2010). The sugar content in the juice extracted from sweet sorghum stalks varies from 16-23%. Sweet sorghum is best suited for ethanol production because of its higher fermentable sugar content in the stalk compared to sugarcane (Reddy & Ramesh, 2005). Ethanol production has become an important new market for grain sorghum due to the classification of grain sorghum as an advanced biofuel feedstock in the 2008 Farm Bill. According to the World Agricultural Supply and Demand Estimate report ethanol production will account for 26 percent of domestic grain sorghum usage Li.,(2014).

MATERIALS AND METHODS

The experimental materials consisted of three selected crosses from NCII mating based on their sugar/brix content. The three crosses are: IS23525 x KSV15, NRS005 x SAMSORG45, and SAMSORG44 x NRS003.Each cross in 2018 was advanced to F_2, BC_1P_1 and BC_2P_2. The non-segregating generations of each of the three crosses (P_1,P_2 and F_1) along with the segregating generation(F_2, BCP_1 and BCP_2) was evaluated during the dry season of 2018 in a Randomized Complete Block design at two locations, IAR Samaru farm and ATBU farm in Bauchi, with 3 replications at each location. Plot size for non-segregating generation will be 5rows of 5mlong with inter and intra row spacing of 0.25m x 0.65m respectively, and for the segregating generation, plot size will be measure 12rows of 5m long with same intra and inter-row spacing as in non-segregating generation. Standard cultural practice for sorghum production will be as described by IAR will be followed throughout the growing condition. Ten competitive plants of parental lines and F_1S and 25 plant of F_2S, BC_1P_1 and BC_2P_2 per replication was randomly be selected for data collections.The knowledge of the genetic make-up of complex quantitative traits and the magnitude of genetic variability that exist among available germplasm are important for breeding of high sugar content genotype(Rao *et al.*, 2013).

RESULTS AND DISCUSSION

Phenotypic and genotypic coefficient of variation were estimated on nineteen traits on six generation (P_1, P_2, F_1 non segregation population) (F_2, BC_1,BC_2 segregation population)) for three crosses in Bauchi wet season and showed PVC ranged from 5.13 of panicle weight to 264.45 of grain yield, while GCV were range from 2.31 of fresh biomass to 84.80% of stem diameter. High heritability were observed in all the traits except in days to fifty per cent flowering,grain yield, Hbs ranged from 31.21 of panicle weight to 48.62 of plant height. Moderate broad sense heritability were observed in all the traits except panicle weight, grain yield. All the traits showed low genetics advance except in brix content at milk 33.67%.While in Zaria wet the PVC ranged from 7.81 for panicle weight to 531.49 for grain yield while the GCV ranged from 1.49 for fresh juice volume to 120.69 of number of leaves. The PCV were higher than GCVs. The broad sense heritability (Hbs) estimates ranged from 5.17 of days to heading to 92.31 of number of leaves. Broad sense heritability ranged from 0.02 of brix content at maturity to 83.78 of panicle weight. The high heritability estimates for days to maturity and plant height suggest that these traits are likely to respond to direct selection. Zou *et al.*, (2011) reported similar estimates of heritability for these traits. The high heritability obtained for most of the traits is in agreement with the findings of (Olukoye *et al,.2015*). Low Hns was observed in all measured traits except plant height, number of leaves number of internode, stem diameter, fresh biomass, fresh juice weight, brix content at dough stage that was moderate. Narrow sense heritability (Hns) were ranged from 2.01 of number of inter node to 74.80 of days to heading. Moderate narrow sense heritability was observed in all the traits except fresh biomass, leave length. All the traits showed low GA estimates of 0.18 for leave length to 19.68 moderate of brix content at dough stage. The effectiveness of selection for any character depends not only on the extent of genetic variability but also on the extent to which such traits can be transferable from one generation to the next.

Table 1. Estimates of Variability, Heritability and Genetic Advance for Morphological, Brix Contents and other Related Traits of Sweet Sorghum Evaluated in the Wet in` Bauchi and Zaria in 2019

	Bauchi Wet Season					Zaria Wet Season				
			Heritability					Heritability		
Traits	PCV	GCV	Hbs	Hns	GA	PCV	GCV	Hbs	Hns	GA
DFH	32.44	13.51	25.05	39.18	0.78	25.04	10.43	5.17	1.20	0.75
DFF	38.49	15.15	13.58	11.87	0.50	25.04	9.86	8.48	8.84	0.70
PLHT	11.05	3.64	54.16	48.62	0.67	10.75	3.86	53.75	23.68	0.29
NOLV	218.22	91.65	91.44	31.58	0.85	287.35	120.69	92.31	75.43	0.63
NOIN	218.22	82.92	98.15	24.74	4.86	242.54	92.16	64.97	44.38	3.82
STDM	188.45	84.80	22.32	14.81	1.15	156.70	70.52	16.21	15.70	0.32
PNWT	5.13	4.61	2.29	1.21	5.42	7.81	7.02	94.19	83.78	1.03
PNLT	39.02	12.41	40.96	33.28	0.86	24.41	7.76	29.15	18.55	1.03
HSW	184.55	27.72	22.39	15.70	2.15	115.97	17.42	33.79	21.91	6.01
GY	264.45	11.07	4.14	1.19	1.31	531.49	25.47	12.73	11.61	4.68
FBM	28.99	2.31	52.34	24.48	1.69	19.91	1.59	38.48	5.01	1.05
FJV	25.80	2.86	82.27	28.46	5.67	18.14	1.52	20.49	18.75	12.23

FJW	27.89	2.81	72.27	26.96	3.93	21.49	1.49	30.01	24.04	8.54
DBM	14.50	12.75	74.63	35.93	0.27	10.44	9.18	17.08	15.92	0.93
BXD	31.83	25.99	23.92	17.14	12.63	30.69	9.88	6.58	4.27	12.28
BXM	51.68	19.69	62.14	56.14	33.67	28.92	24.82	42.34	2.50	25.25
BXMT	43.42	5.48	26.54	16.67	3.54	45.74	5.77	6.32	0.03	6.16
LVLT	18.28	10.10	62.87	58.76	0.56	16.11	11.31	55.53	40.02	3.66
STKLT	42.74	10.81	69.48	36.19	2.53	60.23	15.24	75.71	51.49	0.36

DFF= :Days to 5o% Heading.Days to 50% flowering, PLHT= :Plant height(cm) GY= Grain yield, NOL= :Number of leaves, HSW= Hundred Seed Weight. NON=: Number of internode,, STDM =:Stem diameter(m):FBM= Fresh Biomass. FJV= :Fresh juice volume(kg), ,FJW= :Fresh juice weight(kg)) ,BXM= Brix at milk stage%, BXMT= :brix at maturity. LVLT= Leave Length. STKL= :Stalk length(cm).

Heritability estimates (expressed in %) in broad sense (Hbs) and narrow sense (Hns) and phenotypic and genotypic Coefficient of Variability (PCV) and (GCV), Genetic Advance (GA) were estimated on nineteen traits for six generation (P_1,P_2, F_1, non-segregation population and F_2, BC_1,BC_2) for three crosses of dry season (Bauchi and Zaria). The results were presented in Tables 2. The PCV ranged from 7.64 for panicle weight to 176.78 for hundred seed weight while the GCV ranged from 2.27 for fresh juice weight to 91.80 for brix content at milk stage. In all the traits PCVs were higher than the also Zou *et al.*, (2011) reported similar estimates of heritabilit . The heritability (Hbs) estimates ranged from 8.58 for leave length to 91.80 for number of internode. High heritability was observed for all the traits except fresh juice weight that was moderate (17.86) and leaves length that showed low Hbs (8.58). Narrow sense heritability (Hns) ranged from 6.95 for leaves length to 62.01 for brix content at dough. High Hns was observed for all the traits being >20% with exception of stem diameter, hundred seed weight, grain yield and fresh juice weight which were moderate and plant height (7.28), FJV (8.19) and leaves length (6.95) which were low. The genetic advance was classified as suggested by Johnson *et al*., (1955) (<10%) low, 10-20% moderate and >20% high. The GA ranged from 0.20 for leaves length to 5.93 for fresh juice volume. All the traits showed low GA estimates. All the traits showed low GA estimates except in brix content at dough stage 19.68% indicated moderate genetic advance. While in Zaria Dry the PVC ranged from 8.57 for panicle weight to 794.30 for grain yield while the GCV ranged from 2.70 for plant height to 74.66 of stem diameter.. The PCV were higher than GCVs. The heritability (Hbs) estimates ranged from 13.53 for leave length to 80.40 of days to flowering. High broad sense heritability was observed for all the traits except fresh biomass, fresh juice weight, brix content at dough stage that was moderate. Narrow sense heritability (Hns) were ranged from 2.01 of number of internode to 74.80 of days to heading. Moderate narrow sense heritability was. Observed in all the traits except fresh biomass, leave length. All the traits showed low GA estimates of 0.18 for leave length to 19..68 moderate of brix content at dough stage .

Table 2. Estimates of Variability, Heritability and Genetic Advance for Morphological, Brix Contents and other Related Traits of Sweet Sorghum Evaluated in the Dry in Bauchi and Zaria in 2019

	Bauchi Dry					Zaria Dry				
			Heritability					Heritability		
Traits	PCV	GCV	Hbs	Hns	GA	PCV	GCV	Hbs	Hns	GA
DFH	13.03	8.98	86.46	57.01	3.56	14.78	7.06	80.11	74.80	1.67
DFF	12.94	8.76	87.32	43.42	3.25	15.00	6.72	80.40	75.75	1.51

PLHT	10.29	3.05	32.45	7.28	0.76	11.01	2.70	29.56	17.28	0.72
NOLV	93.89	39.43	30.62	30.07	0.55	171.22	71.91	54.83	26.38	0.92
NOIN	97.59	37.08	91.08	57.57	0.39	173.79	66.04	58.61	2.01	6.34
STDM	119.99	54.00	26.72	13.70	0.65	165.91	74.66	78.97	57.42	2.06
PNWT	7.64	6.87	73.99	24.83	2.00	8.57	7.71	74.44	32.02	2.41
PNLT	38.72	12.31	58.98	57.06	0.48	36.34	11.56	44.72	26.13	1.06
HSW	176.78	26.55	39.73	14.87	1.67	254.00	38.15	79.27	34.97	1.65
GY	703.25	18.65	82.29	12.35	1.27	794.30	30.79	42.40	32.24	1.66
FBM	29.12	2.32	41.25	22.30	0.87	47.62	3.79	16.09	8.46	0.57
FJV	13.98	2.26	21.23	8.19	5.93	25.52	2.83	55.58	11.13	8.63
FJW	12.31	2.27	17.86	10.56	4.71	27.69	2.79	15.36	10.01	2.74
DBM	12.76	11.22	21.78	9.41	1.31	14.79	13.01	48.97	30.49	1.05
BXD	57.06	48.32	81.67	62.01	0.87	35.83	25.56	16.19	15.54	19.68
BXM	52.72	91.80	64.08	37.10	5.71	112.61	64.68	48.77	11.25	3.00
BXMT	71.94	9.08	73.89	59.54	1.46	79.05	9.98	78.78	58.26	1.08
LVLT	26.79	13.52	8.58	6.95	0.20	18.88	4.89	13.53	8.18	2.42
STKLT	76.89	19.46	39.86	35.38	0.41	134.17	33.95	87.02	71.63	0.18

DFF= :Days to 5o% Heading.Days to 50% flowering, PLHT= :Plant height(cm) GY= Grain yield, NOL= :Number of leaves, HSW= Hundred Seed Weight. NON=: Number of internode,, STDM =:Stem diameter(m):FBM= Fresh Biomass. FJV= :Fresh juice volume(kg), ,FJW= :Fresh juice weight(kg)) ,BXM= Brix at milk stage%, BXMT= :brix at maturity. LVLT= Leave Length. STKL= :Stalk length(cm).

RECOMMENDATION AND CONCLUSIONS.

To accomplish any breeding program depends upon the genetic variation in the materials at hand. The greater the genetic variability, the higher would be the heritability, hence the better the chances of success to be achieved through proper selection. In this study most of the traits showed high heritability indicating the possibility of positive response to selection. This indicates the likelihood of transferring the heritable components from parents to offspring during breeding process. The Transgresive sergeants identified in this study could be improved by pedigree or recurrent selection favourable alleles for the improvement of brix component traits

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GENOTYPE-DEPENDENT STRIGOLACTONES EFFECT ON STIMULATION OF *STRIGA HERMONTHICA* (DEL.) BENTH SEED GERMINATION AND INDUCED SYSTEMIC RESISTANCE INDICATORS

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ABSTRACT
Strigolactones, a new group of phytohormones, are reported chemical cues that trigger the germination of Striga. A pot experiment was conducted to investigate the impact of synthetic strigolactone (GR24 at 0.1 mg L^{-1}) and exudates of maize genotype (at 0, 2, 4, 6 mg L^{-1}) on nine crosses of seven parents including: three inbred lines; TZSTR 190, TZSTR 193, TZEI 114 and three open pollinated varieties; SAMMAZ 14, SAMMAZ 16, SAMMAZ 17 and SUWAN and two check varieties GWG 111 and 5005 with different reaction to Striga infestation were selected to identify strigolactones production in maize genotypes using LC/MS/MS analytical procedure as well as their stimulation of Striga seed germination in a germination assay. The results of the LC/MS/MS showed that only two genotypes namely SUWAN X SAMMAZ 17 and Check GWG111 produced a detectable amount of the compound as that of the standard GR24 (m/z 321. However, when subjected to 4 different concentrations (0mg/L, 2mg/L, 4mg/L and 6mg/L) of the root extracts showed GR24 at 6mg/mL and 4mg/mL gave the highest Striga seeds germination of 68.83 and 47.00 respectively, while TZSTR 190 at 2mg/mL had the least Striga seeds germination of 19.33. It is suggested that Striga germination depends on maize genotype and concentration of the strigolactone and the use of LC/MS/MS analytical procedure to study the level of concentration in which GR24 and exudates from maize genotypes could play a vital to identify tolerant genotypes is extremely imperative and can open novel horizons for future investigations in the management of the parasitic plant.
Keywords: *Striga, LC-MS-MS, Germination Assay, Strigolactone, GR24, Open Pollinated Varieties,*

INTRODUCTION
The root obligate hemiparasite *Striga hermonthica* is one of the major global biotic threats to agriculture in sub-Saharan Africa, causing severe yield losses of cereals. The germination of *Striga* seeds relies on host-released signaling molecules, mainly strigolactones (SLs). Many seed germination stimulants have been extracted and identified in parasitic weeds host and non-host plant (Li et al., 2020; Sato et al., 2014). Among the germination stimulants of parasitic weeds in host plants are three distinctive classes of compounds which include, dihydroquinones, strigolactones, and sesquiterpene lactones (Li et al., 2020).

Maize plant produces at least two strigolactones, strigol and sorgolactone (Sato et al., 2014). Jamil et al., (2011) in their work reported some common SLs like sorgomol and 5-deoxystrigol and some yet to be named putative SLs, SL1 and SL2 with molecular mass of 348 and 376, respectively in maize. However, recent studies by Charnikhova et al., (2017) have shown the presence of seven unidentified SLs and 2 new structures were identified in maize.

Strigolactones produced by individual plant are usually unstable and very low in concentration for isolation and characterization using ODS-HPLC separation (Sato et al., 2014). Recovery in a culture filtrate using this method is put at as low as 2 % there by making it unfit for low strigolactones producing plant like maize. However, the use of a simple and fast analytical tool known as HPLC-tandem mass spectrometry (LC/MS/MS) has been reported for adequate identification, isolation, characterization and quantification of biomolecules in samples (Ismail et al., 2019; Jamil *et al*., 2011; Motmainna *et al.*, 2021; Peixoto Araujo *et al.*, 2020).

The objective of this present study is to identify the presence of strigolactones in some selected hybrids of maize identified with high, low and moderate *Striga* infestation in potted glass house experiment as well as their parents using LC/MS/MS. The study also examines the relationship between the strigolactones production and *Striga* seed germination stimulation in maize.

MATERIALS

Planting material

A pot experiment was conducted in a glass-house of Ladang 15 (2°59'05.7"N, 101°44'02.9"E, 30 m above average sea level) at the Agricultural Research Park, Institute of Tropical agriculture and Food Security, Universiti Putra Malaysia. Maize seeds of nine crosses and their reciprocals hybrids out of 42 hybrids derived from 7 x 7 diallel single cross, their seven parents and two check varieties with different reaction to *Striga* infestation were tested . The crosses and their reciprocals selected include: recip. SUWAN x SAMMAZ 16, cross SAMMAZ 14 X SUWAN, TZRST 190 x TZSTR 193; TZSTR 190 x SAMMAZ 14, SAMMAZ 17 x TZSTR 190 and SAMMAZ 14 x TZSTR 193, SUWAN x TZSTR 193, SUWAN x SAMMAZ 17, SAMMAZ 16 X TZSTR 190, the parents, TZSTR 190, TZSTR 192, TZEI 114, SAMMAZ 14, SAMMAZ 16, SAMMAZ 17 and SUWAN and the check varieties 5005 and GWG 111. The seeds of maize and *Striga* used in the experiment were supplied by International Institute for Tropical Agriculture, Ibadan, Nigeria and green W Seed company.

Exudate extraction procedure and sample preparation for LC-ESI-MS/MS

The exudate extraction was carried out at Weed Science Laboratory of Department of Crop Science, Faculty of Agriculture, Central Laboratory and Physiology Laboratory of Institute of Tropical Agriculture and Food Security, University Putra Malaysia. Seeds from Eleven hybrids, their parents and two check varieties of maize were sterilized in 70 % ethanol (EtOH) for 2 minutes and then 1% sodium hypochlorite (NaOCl) for 5 minutes. The seeds were thoroughly rinsed using distilled water. The seed were germinated in petri dishes with moistened filter paper for 7 days at 28°C in the dark (Plate 1A). Ten germinated seedlings from each variety were transferred into Nalgene (115ml filter units and 0.8 micromillimeter pore) with 2 cm glass wool fibre in the filter unit and moistened with 5 ml half strength Hoagland's nutrient solution as culture medium (Plate 1 B&C). The culture medium in each filter were removed by suction and replace with a fresh solution at two days interval for three weeks. The set up were placed under inflorescence illumination at 25 ± 1 °C temperatures. The exudates were collected by washing the filter with 150 ml of sterile water after 24 hours and fresh sterile water added. The collected root exudates were extracted 3 times with 100 % LCMS GRADE acetone and stored in -20°C. The acetone extracts were combined and washed using 0.2M of K_2HPO (pH 8.4), dried over anhydrous $MgSO_4$, stored in -80°C and later concentrated using Freeze dryer. 4 µg/mL solution of the freeze-dried acetone extracts from each sample were prepared using 55 % LCMS GRADE methanol, vortexed and filtered through 0.2 µm spin columns into sterile glass vials for LC-QTOF-MS/MS analysis.

Under a sterile condition, *Striga* seeds surface were sterilized in 2% Sodium hypochlorite containing 0.02% (v/v) Tween20 for 5min and rinsed thoroughly with distilled water. The seeds were dried for 30 mins in a laminar air flow cabinet. Approximately 100-150 seeds were spread on a glass fibre filter paper (GFFP) disc (9cm diameter) and placed in sterilized petri dishes (9cm diameter) and covered with Whatman filter paper as described by Jamil et al., (2011) & Jamil et al., (2018). The set up were wetted with 2.7ml of distilled water, sealed with parafilm and incubated in darkness at 28^{o}C for 12days. The set ups were checked regularly and water added when necessary. After preconditioning, 1g of the preconditioned seeds were dissolved in 99ml of distilled water (1:99) and 100µl were pipetted into petri dishes containing folded tissue papers.
LC-ESI-MS/MS analysis was carried out on the root extracts of the eighteen genotypes of maize by measuring 2 µg/mL samples from sub-section and GR24 standard. Thermo Scientific Ultimate 3000^{TM} Q Exactive^{TM} Hybrid Quadrupole Orbitrap mass spectrometer with an ESI attached to a UHPLC binary pump autosampler (Macherey-Nagel, Düren, Germany). Separation was performed using Water Acquity UPLC^{TM} BEH a C18 reversed-phase column (100 x 2.1 mm, 1.9 µm) (Ireland). The mobile phase was A-0.1% formic Acid in water B- 0.1% formic acid in Methanol) with flow rate of 0.5ml/min and injection volume of 5ul and PDA range of 190-600nm. 0-11 minutes: 95% A: 5% B, 12–15 minutes: 10% A: 90% B, 15–17 minutes: 95% A and 5% B. It remained isocratic 20 minutes at: 95% A: 5% B. The injection volume was 5 µL. The mass acquisition data was operated at both negative and positive switch modes, with a voltage of 4.0 kV, capillary temperature 350°C, sheath gas flow rate 80 arbitrary units, and a scan range m/z 150 to 2000 respectively. Data acquisition was performed using Xcalibre 2.2. SP 1.48 (Thermo Fisher Inc) software.
Four different concentrations: 0µg/mL (Blank 55% methanol) as negative control, 2µg/mL, 4µg/mL and 6µg/mL of freeze-dried acetone extracts from each sample and GR24 standard (positive control) were prepared in 55% Methanol. 10 µL of each sample solution were pipetted into each petri-dish containing *Striga* seeds in triplicates arranged in a factorial completely randomized design CRD, sealed using paraffin to maintain moist condition and incubated in the dark at room temperature (25 ± 1 ^{o}C) for 5 days.
Number of germinated *Striga* seedling at 5 days after incubation was recorded.
The data collected were subjected to analysis of variance and the mean separated using Fisher's Least Significant Difference (LSD) at 5% significance difference.

A **B** **C**

Plate 1: Picture showing Strigolactone extraction process

RESULTS AND DISCUSSION
LC/MS Analysis of samples
The LC/MS analysis on the standard showed the value of GR24 to be m/z 321.07 on the full scan (Fig A). The ms/ms fragment showed fragments at m/z 321, m/z 224 and m/z 11 at 3.95 retention time. This agrees with the report of Rial et al., (2018). The only genotypes that showed same compounds as the standard at 3.95 retention time are hybrid recip. SUWAN X SAMMAZ 17 and Check GWG 111. The full ms scan of hybrid recip. SUWAN X SAMMAZ 17 and Check GWG 111 as well as the ms/ms fragments of m/z 321, m/z 224 and m/z 11 is shown in figure B and C. This result is also in agreement with the report of Rial et al., (2018).

Analysis of variance for *Striga* seed germination at 5 days

The analysis of variance for mean squares of *Striga* seed germination at 5 days for first and second season are presented in appendices 29-30. The combined analysis results for *Striga* seed germination assay arranged in a two factorial design is presented in Table 2.

The mean squares from the analysis of variance in a combined season as well as the mean interaction of treatment x concentration of the methanol-based root extract from 27 maize genotypes and analog synthetic Standard GR24 in a *Striga* seed germination assay is presented in Table 2 and 3.

Result in Table 2 shows that the effects of treatment, concentration and their interactions on germination of *Striga* seeds were highly significant. This indicates that the germination of *Striga* seeds is dependent on the treatment (genotypes) and the concentration of strigolactones in the root extracts formulation. This is in line with the findings of Mohemed et al., (2018) & Motmainna et al., (2021). Also, the combine analysis shows a highly significant

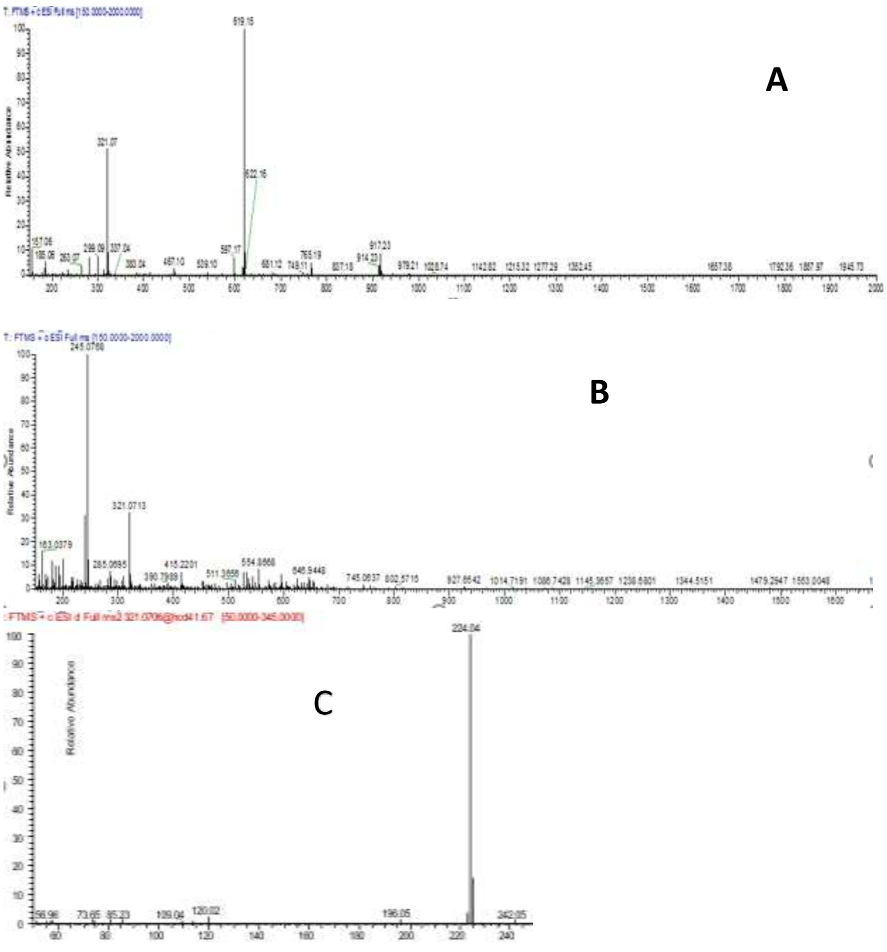

Figure.1: LC-MS analysis showing peak for the of Strigolactone in sample MS/MS fragmentation of Standard Strigolactone GR24 (A) and Strigolactone in hybrid recip. SUWAN X SAMMAZ 17 (B).and Check GWG 111 (C)

Table 1: Analysis of variance for *Striga* germination at 5days after treatment in combined Season

Source of variation	df	MS
Season	1	363.15**
Treatment	27	825.71**
concentration	3	24450.82**
Treatment x season	27	159.86**
Treatment x conc.	81	142.23**
Treatment x season x conc.	84	34.42**
Error	224	
Total	335	

**highly significant at p=0.001

Difference in the seasons. This could be as a result of increase in the duration of *Striga* seeds conditioning. The longer the period of pre-conditioning, the higher the viability or germination of *Striga* seeds. This is in in line with the work reported by Charnikhova et al., (2017) & Jamil et al., (2011).

The mean interactions between treatment and extracts concentration on *Striga* seed germination as shown in Table 3 indicates that GR24 at 6mg/mL and 4mg/mL have the highest *Striga* seed germination of 68.83 and 47.00 respectively (Plate 3A),

Table 2: Mean interaction for Treatment and Concentration for *Striga* seed germination at 5 day after treatment for combined season

Treatment/conc	0 mg/mL	2 mg/mL	4 mg/mL	6 mg/mL	Mean	LSD	
GR24	0.00d	24.00c	47.00b	68.83a	34.96a	5.77	2.29
TZSTR190	0.00c	2.00c	7.67b	19.33a	7.25o	3.92	
TZSTR193	0.00c	18.83b	34.67a	43.17a	24.17b	10.42	
TZEI114	0.00d	5.50c	14.67b	21.00a	10.29lm	3.44	
SAMMAZ 14	0.00d	11.50c	20.83b	28.00a	15.08fgh	3.81	
SAMMAZ 16	0.00d	15.50c	23.50b	32.50a	17.88de	3.50	
SAMMAZ 17	0.00d	9.83c	17.00b	24.83a	12.92ijk	2.90	
SUWAN	0.00d	16.00c	25.67b	33.00a	18.67cd	5.01	
SAMMAZ 14 X TZSTR193	0.00d	13.33c	22.33b	30.00a	16.42ef	3.66	
TZSTR193 X SAMMAZ 14	0.00d	3.67c	10.00b	18.83a	8.13no	2.93	
TZSTR193 x SUWAN	0.00d	7.00c	14.50b	19.17a	10.17l-o	2.52	
SUWAN x TZSTR193	0.00c	15.33b	27.67a	30.00a	18.25cde	4.98	
SUWAN X SAMMAZ 17	0.00d	7.50c	13.50b	20.67a	10.42lm	2.28	
SAMMAZ 17 X SUWAN	0.00d	13.50c	21.17b	30.33a	16.25efg	6.82	
SAMMAZ 14 X SUWAN	0.00d	6.33c	21.17b	28.83a	14.08hij	4.60	
SUWAN X SAMMAZ 14	0.00d	3.33c	12.50b	18.17a	8.59mno	2.34	
SAMMAZ 16 X SUWAN	0.00c	13.67b	21.50b	32.00a	16.79def	8.41	
SUWAN X SAMMAZ 16	0.00d	11.17c	17.00b	27.67a	13.96hij	4.87	
TZSTR190 X SAMMAZ 16	0.00d	10.67c	19.83b	26.17a	14.17g-j	5.75	
SAMMAZ 16 X TZSTR190	0.00d	5.00c	13.67b	17.50a	9.04l-o	3.83	
SAMMAZ 17 X TZSTR190	0.00d	8.00c	20.83b	31.00a	14.96f-i	6.17	
TZSTR190 X SAMMAZ 17	0.00d	10.67c	24.00b	34.33a	17.25de	6.07	
TZSTR190 X TZSTR193	0.00d	7.33c	15.33b	21.83a	11.13kl	5.65	
TZSTR193 X TZSTR190	0.00d	3.50c	12.33b	20.67a	9.13l-o	3.05	
TZSTR 190 X TZEI 114	0.00d	7.50c	13.33b	20.17a	10.25lm	3.06	
TZEI 114 X TZSTR 190	0.00d	4.17c	10.50b	16.50a	7.79o	3.16	
CHECK 5005	0.00d	7.83c	19.17b	24.33a	12.83jk	3.13	
CHECK GWG 111	0.00d	14.33c	23.17b	43.67a	20.29c	7.57	
Mean	0.00d	9.89c	19.45b	27.95a	14.32	0.72	
LSD					2.11		

followed by check GWG111 (43.67) at 6mg/mL (Plate 3E) and parent TZSTR 193 (43.17) at 6mg/mL (Plate 3D).While TZSTR 190 at 2mg/mL had the least *Striga* seeds germination of 19.33 (Plate 3C), however, there was no significant difference with the control at concentration of 2mg/mL (Plate 3B). This was followed by SUWAN X SAMMAZ 14 (3.33), TZSTR 193 X TZSTR 190 (3.50) and TZSTR 193 X SAMMAZ 14 (3.67) at concentration 2mg/mL. The overall mean showed that GR24 has the highest numbers of germinated *Striga* seeds of 34.96 which was significantly different from the TZSTR 193 which has the second highest *Striga* seed germination of 24.17. this was closely followed by Check GWG 111 (20.29), SUWAN (18.67), SUWAN X TZSTR 193 (18.67) while TZSTR 190 has the least overall *Striga* seed germination of 7.25 (Plate 3C), followed by TZEI 114 X TZSTR 190 with 7.79, TZSTR 193 x SAMMAZ 14 (8.13) and SUWAN x SAMMAZ 14 (8.59). However, there was no significant different between the two genotypes with the least in the overall *Striga* seed germination.

The result also shows that increase in concentration of the root extract solution across all genotypes and Standard GR24 gave a corresponding increase in *Striga* seed germination except TZSTR 190 at 0mg/L and 2mg/L, TZSTR 193 and SUWAN X TZSTR 193 at 4mg/L and 6mg/L respectively, as well as SAMMAZ 16 X SUWAN at 2mg/l and 4mg/L.

It is interesting to note that there was significant difference in the *Striga* seeds germination between most crosses and their reciprocals, indicating that there could be reciprocal or maternal effects in the inheritance of strigolactones production by the maize plants. This further validates the result of obtained in the *Striga* infestation reaction potted experiment as presented in chapter five which is indicated significance in reciprocal and maternal effect in *Striga* count at 7 and 10 weeks after planting. This is in line with the reports of Adetimirin et al., (2000).

CONCLUSION

All root extract exudates from 27 different genotypes used in this present study were carefully examined by LC/MS/MS for the presence GR24 (M/z 321), only two of the genotypes namely SUWAN X SAMMAZ 17 and Check GWG111 produced a detectable amount of the compound under the conditions used in this study. However, they all stimulated the germination of *Striga* seeds in various degrees at different concentrations of the root extract solution in a germination assay conducted. This shows that either they amount produced by the other genotypes were too minute to be detected or other forms of strigolactones were present in the root. It may be concluded that different genotypes produce different mixtures of stimulant and at different concentration which could be very low for detection by the procedure used in this study. However, further studies using different higher concentrations of the root extracts in an LC/MS/MS analysis should be conducted, in order to allow for identification of stimulants present in samples.

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GENE ACTION FOR GRAIN YIELD AND SOME QUALITY TRAITS IN CORN (*ZEA MAYS* L.) USING DIALLEL CROSS ANALYSIS

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ABSTRACT
Information on combining ability facilitates efficient utilization of genetic materials in a breeding program. Selection of suitable breeding-lines is desirable in crop improvement and requires complete knowledge about the nature of gene action involved in the inheritance of quantitative and quality traits. Gene action of grain yield and quality traits in maize (Zea mays L.) was studied through crossing 8 parental lines in half diallel mating design (griffing method II model I). The parents and the 28 progenies were laid out in randomized complete block design (RCBD) with three replications. The result combined of analysis of variance revealed significant (p<0.05) variation among the genotypes and the parent TZSTR190 was the best combine for major yield contributing characters including plant height, ear length, number of rows per cob, grain yield, starch content and protein content. The GCA: SCA ratio and GCA x Env, SCA x Env Specific combining ability estimates showed that desirable SCA effects in Crosses TZSTR190 x TZSTR193 and TZSTR166 x TZSTR 193 for all traits studied except ear height and number of rows per ear. Gene action analysis revealed preponderance of both additive and non-additive genes for yield and quality traits. Therefore, for varietal improvement, these crosses could be useful towards enhancing maize yield and quality.
Keywords: *Maize, Gene action, General and specific combining ability, grain yield and quality traits*

INTRODUCTION
Maize (*Zea mays* L.) occupies a prestigious place in world agriculture. It is a Miracle crop in view of its widespread usage as human food, animal feeding and industry (Keskin *et al*., 2005). Maize can be grown over diverse geographical environments compared with other crops. The identification of parental inbred lines that perform superior hybrids is the most costly and time consuming phase in maize hybrid development. Per se performance of maize inbred lines does not predict the performance of maize hybrids for grain yield (Hallauer and Miranda, 1988) predictors of single cross hybrids value or heterosis between parental inbred lines could therefore increase the efficiency of hybrid breeding programs (Betran *et al*., 2003). Plant breeders and geneticists often use diallel mating design to obtain genetic information about a trait of interest from a fixed or randomly chosen set of parental lines (Murray *et al.*, 2003).

The combing ability analysis is an important method to know gene actions and it is frequently used by crop breeders to choose the parents with high general combining ability GCA) and hybrids with high specific combining ability (SCA) effects (Yingzhong, 1999). Beside gene effects, breeders would also like to know how much of the variation in a crop is genetic and to what extent this variation is heritable because efficiency of selection mainly depends on additive genetic variance influence, the environment and interaction between genotype and environment (Haron *et al*., 2014). Large genotype x environment effects tends to be viewed as problematic in breeding because the lack of a predictable response hinders progress from selection (Dudley and Moll, 1969).

The knowledge on the genetic system controlling the quantitative and qualitative traits is important for formulating an efficient selection program through the use of a suitable mating design (Arti and Sonia, 2015). The information about the relative contribution of components of variation viz; additive and non-additive is essential for effective crop important program (Azhar and Ajmal, 1999). In order to apply an optimum breeding strategy of targeted qualitative and quantitative trait, a genetic analysis of the traits needs to be performed. Diallel mating design has been used extensively by several researchers to measure gene action for yield and yield component of maize (Mahdi *et al.*, 2010). Several workers studied gene action on the yield and yield attributes and determined that additive and non-additive variance components are important in the genetic control of yield and its associated traits in maize (Haron *et al*., 2014, Gideon *et al*; 2017). The present investigation was therefore, undertaken to study the estimates of general and specific combining ability and gene action in maize for yield components and quality traits.

MATERIALS AND METHODS

Eight maize inbred lines viz: TZSTR166, TZEI114, TZEI80, TZEI88, TZSTR190, TZSTR193, TZSTR115 and TZEI25were chosen based on their performance for yield and reaction to *Striga* in this study to represent an amount of genetic diversity of various agronomic traits. They were crossed in the raining season of 2015 at the University of Agriculture Research field, Makurdi in half diallel to give 28 crosses excluding reciprocals. The parents and their 28 F_1 hybrids were evaluated using RCBD with three replication in 2016 at 2 environments; the research farm of University of Agriculture, Makurdi and the research station of College of Agriculture, Science and Technology Lafia Lat 8º 32'N and 8º 32ºE) above sea level, Nasarawa State. At both environments, the parents and their progenies were sown in three-row plots of 3 x 1.5m. Two seeds were sown at inter-row spacing of 0.75m within intra row spacing of 0.50m and were later thinned to one plant per hill at two weeks after sowing (WAS) to obtain a population of 53, 333 plants per hectare. At four weeks after sowing (WAS); the plots were hoemanually weeded to keep the trial free from weeds. Supplementary hoe weeding was carried out at eight weeks after sowing. A compound fertilizer (NPK 15:15:15) was applied at the rate of 30kg/hectare three weeks after sowing while urea was applied at the rate of 20kg/hectare after first weeding (6WAS). Data were collected from both environments on days from emergence to silking, days from emergence to maturity, plant and ear height (cm), ear length (cm), number of rows per ear, number of kernels per ear, seed yield per hectare (kg), starch content and protein content. Data collected at both environments were subjected to analysis using Griffing (1956) method II model I (fixed effects). Both general and specific combining abilities (gca and sca were computed using SAS Procedure (1999) for the parents and hybrids respectively. At the statistical model for RCBD and that of diallel method II model I to be provided as a guide for the analysis.

RESULTS AND DISCUSSIONS

An important step in a breeding programme is to adopt a suitable breeding strategy for the purposeful management of generated variability which largely depends upon type of gene action in the population for the traits under genetic improvement (Sprague, 1966). A knowledge of gene action helps to set an appropriate breeding strategy to accumulate fixable genes through selection. Genetic improvement in seed yield has been the priority of breeders. Genetic analysis helps in identifying traits for improvement of yield potential (Arti and Sonia, 2015).

Results of combined ANOVA across environment revealed that environment effects were significantly ($P<0.01$) different for all the traits measured (Table 1). This indicates that the lines do not perform the same across environments for most of the traits. Other authors inferred that environmental effects were significant for days from emergence to silking, plant height (Mickelson *et al.*, 2001, Abimiku, *et al.*, 2020) number of kernels per row (Vidal Martinez *et al*., 2001) and grain yield (Doerkben *et al.*, 2003). Genotype x environmental interaction effects were significantly ($p<0.05$)for all the traits except for Number of rows per ear suggesting that the genotypes performed differently for these across the two environments and specific genotype could be selected for different environment.

Non-significant genotype x environment interaction effects indicated that selection for days from emergence to silking, ear length and grain yield at one environment might be effective for a broad range of environments. Genotypes x environment interaction effects were significant for other traits, suggesting that genotypes did not perform same in the environments (Table 1). Some researchers have reported genotype x environment interaction effects for days from emergence to silking, plant height (Mickelson *et al*., 2001) number of rows per ear, ear length and grain yield (Doerksen *et al*., 2003; Mickelson *et al*., 2001).

Genetic variability of genotypes was significant for all traits. Therefore, the genotype sum of squares was partitioned into GCA and SCA (Table 1). Haron *et al.* (2014, Abimiku, *et al.*, 2020) similarly revealed that genotype effects were significantly ($p<0.05$) different for all the traits measured which showed that these genotypes perform differently across both environments. The results also showed that both general combing ability (GCA) and specific combining ability (SCA) was highly significant ($P<0.01$) for all the traits, indicating the importance of both additive gene action is important in the inheritance of these traits (Table 1).GCA x environment interaction effects were significant for all traits except days from emergence to silking and plant height while SCA x environment interaction effects were significant for all traits except ear length and grain yield. This indicate that hybrids performed the same across both environments in yield.

Estimate of Genetic Components of Variances:

The nature of gene action has been inferred from the estimates of GCA and SCA variances. The estimates of combining ability variances (σ^2gca and σ^2sca) and the ratio of δ^2A/δ^2_D is presented in Table 2. In this study plant height, ear height, ear length, number of row per ear number of kernels per row and grain yield showed non-additive gene effects, indicating preponderance of non-additive gene effects for inheritance of these traits. This predominance of SCA

variance denotes that non additive genetic effect were largely influencing the expression of the traits, hence heterosis could be exploited for can be exploited in producing high performing hybrids. These results were in agreement with the report of other researchers about predominance of non-additive genetic effects for plant height and ear height (Alam *et al*., 2008) ear length and number of rows per ear (Saeed *et al*., 2000), number of kernels per row (Srdic *et al*., 2007) and grain yield (Srdic *et al*., 2007). In contrast to this result other researchers indicated predominance of additive genetic effects for plant height (Vacaro *et al*., 2002), number of rows per ear (Srdic *et al*., 2007) number of kernels per row (Saeed *et al*., 2000) and grain yield (Ojo *et al*., 2007) days to emergence to silking and days to harvest traits showed additive genetic effect indicating additive genetic effects was more important than non-additive genetic effect in controlling the inheritance of these traits.
In the present investigation, the comparative estimates of σ^2sca, σ^2gca, σ^2A, σ^2D and σ^2A/σ^2D revealed that non-additive gene action is controlling the expression of ear length, number of rows per ear and grain yield per plant. The traits viz; plant height, ear height, days to emergence to silking and days to harvest duration are controlled by additive gene action as the ratio δ^2A/δ^2D is greater than unity hence pedigree selection could be exploited for these traits. These results are in conformity to findings of Mahdi *et al.* (2011) and Kumar *et al* (2014). However, contradictory reports are also available in literature with respect to gene action studies which can be due to different genetic material used in the present study. Since both additive and non-additive variances were found to be important in the genetic control of all quantitative and qualitative traits in this study, the use of population improvement method in the form of diallel selective mating or mass selection with concurrent random mating may lead to release of new maize varieties with higher yields.
Estimates of general combining ability for various traits have been presented in Table 3. The estimates of GCA effects exhibited that the parent TZSTR190 was the best general combiner for most traits studied i.e. days to silking, ear length, number of rows per cob, grain yield, starch content and protein content. This parent is most suitable for good yield performance at both environments.).. TZSTR 166 exhibited desirable GCA effects for plant height, ear length, number of rows per cob, grain yield, starch content and protein content Therefore this parent could be used extensively in hybrid program to increase maize yield with quality similar to the investigation reported for the following characters i.e. plant height (Vacaro *et al*; 2002) number of rows per cob (Rodrigues and da Silva, 2002).
High positive estimates of specific combining ability (SCA) in absolute values, indicates that hybrid performance is relatively superior to parent. In the selection of parental lines used to produce hybrids, the effect of SCA analyzed in isolated way has a limiting value. Therefore other parameters should be considered such as the average of hybrids and GCA of the respective parent lines (Dhasarathan *et*, *al*., 2015). Thus, superior hybrid combinations, which are important for breeding, are involved with at least one parental line that has the most favorable effects of GCA (Cruz and Regazz, 1997). Therefore it is possible to analyze the 2 hybrids that showed high performance for most of the yield quality and quantitative traits such as TZ5TR166 x TZ5TR190 and TZ81Z190x TZSTR190 (Table 4.)
The maize yield in the hybrid TZSTR190 x TZSTR193 is associated with high effects of GCA of both parental lines. Therefore, in this case, the high productivity is not due to dominant genetic effects of inbreds but to additive effect. In the TZSTR190 x TZSTR193 hybrid, it is associated with one of the highest effects of the GCA of the TZSTR190 inbred with one of the highest effects of the estimated SCA – since TZSTR193 inbred showed lower GCA. In this case, the participation of SCA is significant for hybrid yield, contributing almost to the GCA from both inbreds, regarding the dominance and epistasis effect (Gardner, 1963). However, hybrids TZSTR166 x TZSTR190 and TZSTR166 x TZSTR193 both exhibited high SCA for grain yield, plant height, ear length starch content and protein content, while TZSTR190 x TZSTR193 showed highest SCA for starch content and protein content. About seven hybrids exhibited higher mean performance and SCA effects of maize yield. In respect of maize yield superiority, it is decided by its quality. Therefore, crosses TZSTR190 x TZSTR193 and TZSTR166 x TZSTR193 recorded the highest mean and SCA effects for yield and quality traits. This present study revealed that most of the yield and quality traits include, plant heights, ear length, number of rows per cob, starch content and protein contents are governed by both additive and non-additive genes.

CONCLUSION

Sufficient genetic variability was generated for yield and related traits after crossing eight diverse inbreds of maize in half-daillel planting design. TZSTR190 and TZSTR193 were the best among parents as they showed desirable mean and GCA effects for most yield and its contributing traits and yield and quality traits respectively. Therefore, these parents could be used extensively in hybrid breeding program with the view to increase maize yield with quality. However, based on mean and SCA effects, two hybrids TZSTR166 x TZSTR193 and TZSTR190 x TZSTR193 proved to be the best to increase yield with better quality. For varietal improvement, these hybrids could also be used for exploiting promising recombinants and it could be useful to increase maize grain yield and quality.

Table 1: Combined analysis of different traits of maize based on Griffing method 2 model 1 model 8 x 8 diallel cross evaluated at -Makurdi and Lafia in 2019

Traits	source of varieties	Days from emergence to silking	Days from emergence to maturity	Plant height (cm)	Ear heights (cm)	Ear length (cm)	Number of rows per ear	Number of kernel per row	Grain yield of (per plant)
Environment	1	111.41*	334.04*	670.34*	2772.54*	1014.41*	803.314**	1206.46*	1.42**
Rep/Envt.	4	93.1*	149.50*	827.84*	1155.26*	45.11	14.37*	21.33	3.42*
Genotype.	63	22.21*	28.11*	6460.30**	281.57*	3.66*	24.93*	93.16*	4.28*
GCA.	7	34.24*	71.33**	1749.05**	1329.20**	4.32**	252.40*	286.37*	4.99*
SCA.	28	21.17*	14.29*	2408.884**	3241.03*	3.08*	23.17*	141.22*	5.27*
Genotype x Envt.	63	25.17**	56.99*	313.23*	1211.63*	6.66*	9.00*	21.097	3.00**
GCA x E.	7	22.54*	112.70*	836.98*	249.07*	47.58*	25.29*	79.11*	4.91
SCA x E.	28	24.02*	24.11*	1457.81*	122.66	8.66*	8.35*	66.24*	2.16ns
Erorr.	252	4.31	2.85	172.88	132.09	2.53	1.81	20.16	2.04
Total.	**356**								

Days from emergence to silking, Days from emergence to maturity, Plant height (cm), Ear heights (cm), Ear length (cm), Number of rows per ear, Number of kernel per row, Grain yield of (per plant).

Table 2: Variance due to general and specific combining ability and their ratio for different quantitative and qualitative traits in maize

Traits	σ^2GCA	$\sigma^2\delta$SCA	$\sigma^2\delta$A	$\sigma^2\delta$D	$\sigma^2\delta$A/ $\sigma^2\delta$D
Plant height	29.37	44.03	58.74	44.03	1.34
Ear height	28.02	31.00	56.04	28.02	1.81
Day from emergence to silking	61.64	28.92	123.08	28.92	4.26
Days to harvest	71.82	38.102	143.64	38.102	3.77
Ear length (cm)	4.34	17.08	8.68	17.08	0.51
Number of rows/ear	6.85	15.60	13.70	15.60	0.88
Number of karnel/row	8.11	9.06	16.22	9.06	1.79
Grain yield/ha	14.96	31.18	28.92	31.18	0.96
Quality traits:	0.56	8.76	1.12	8.76	0.64
Starch content.	0.05	0.93	0.10	0.05	0.06

δ^2GCA = general combining ability variance, δ^2SCA = specific combining ability variance, δ^2A = additive variance, δ^2D = dominance variance and δ^2A/ δ^2D = ratio of additive variance / dominance variance.

Table 3: Estimate of GCA Effect for Maize Grain Yield and Agronomic Traits in Lafia and Makurdi Locations.

Parents		**PHT(cm)**		**EHT**		**DYSK**		**ELT**		**NRC**		**Grain yield**		**Starch content**	**Protein Content**
		Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	mean	GCA	Mean	GCA		
P1	TZSTR166	163.23	2.28	57.1	1.60	59.33	1.05	56.33	2.19	1.85*	1.31*	56.33	0.47*	0.47*	0.34*
P2	TZEI114	111.92	-2.06	51.93	-10.71*	55.67	-2.93*	59.16	-2.35	-2.85*	-2.69*	59.16	-0.39*	-0.39	-0.62
P3	TZEI80	149.5	-5.05	68.67	-0.89	56.35	0.15	57.33	-1.69	-2.85*	-2.19*	57.33	0.34*	0.34	-0.38
P4	TZEI188	140.30	-5.71	56.9	-3.85	56.00	-4.28	56.33	-1.69	-2.84*	-2.52*	56.33	0.17*	0.17	-0.49*
P5	TZSTR190	164.00	10.62*	69.33	0.76*	61.33	0.45*	56.33	1.15	2.14*	0.48*	56.33	2.46*	2.46*	1.96*
P6	TZSTR193	150.5	5.00	72.33	-1.08	61.67	-4.10	54.33	2.31	2.31*	1.98*	54.33	0.71*	0.71*	0.32*
P7	TZSTR115	143.77	-17.78	68.7	-6.85	65.33	-5.43	56.00	4.81	5.98*	4.31*	56.00	0.43*	0.43	-0.42*
P8	TZEI25	156.3	11.70	56.07	1.84*	58.00	1.42*	56.00	-1.35	-1.02	0.31*	56.00	0.23*	0.23*	0.01

* * = Significant at P< 0.05.

Key: PHT = Plant height, EHT = Ear height, D50F = days to 50%silking, ELT = Ear length , NRC = number of rows per cob, grain yield per hectare, starch content and protein content.

Table 4: Specific Combining Ability Effects for Maize Grain Yield and Agronomic Characters in Lafia and Makurdi in Two Years.

Hybrid	Grain yield (t/ha)		Plant height (cm)		Ear height (cm)		Days to silking		Ear length		NRC		Starch content	Protein content
	Mean	SCA.	Mean	SCA.	Mean.	SCA.	Mean.	SCA	Mean.	SCA.	Mean	SCA		
TZSTR166×TZEI114	6.06	0.75*	163.23	0.24*	57.1	2.09*	57.67	-0.31	1.27	-1.00	12.3	0.030	-0.27	2.55*
TZSTR166 ×TZEI80	5.31	0.13	111.92	-4.82*	51.93	-2.54	54.00	-0.36*	2.17	-1.17*	13.7	0.622	-0.56	1.96*
TZSTR166 ×TZEI188	4.00	0.24*	149.5	0.87	68.67	-3.12	56.33	0.76	2..25	-1.14*	12.4	0.721	0.24	1.67
TZSTR166×TZSTR190	5.51	1.41*	140.30	19.87*	56.9	1.18*	56.00	2.05*	1.85	1.76*	13.2	0.128	1.43*	2.34*
TZSTR166×TZSTR193	6.70	0.58*	164.00	2.18*	69.33	3.18	55.67	0.15*	3.01*	-0.53	14.11	0.781	0.55	2.87*
TZSTR166 ×IITATZSTR1159	5.70	0.33	150.5	-5.20	72.33	-0.86	58.00	0.31*	2.27	0.83*	13.3	-0.12	-0.54	0.78
TZSTR166 ×TZEI25	5.26	0.13	143.77	12.29*	68.7	2.48*	56.67	0.30	3.09*	-0.44	12.2	0.45	-0.76	0.76
TZEI114×TZEI80	4.41	-0.21	156.3	-6.43	56.07	2.78	53.67	-1.13*	1.81	-0.88*	12.2	0.46	0.57	0.77
TZEI114 ×TZEI188	4.27	0.26	158.5	5.82	71.87	-6.55	55.33	-0.78	2.11	0.25	12.9	-0.17	4.11*	2.78*
TZEI114 ×TZSTR190	4.34	-0.35	179.33	3.48	64.93	-0.23	55.33	0.19	2.50	0.01	13.2	0.92	0.12	0.09
TZEI114 ×TZSTR193	3.33	-0.20	147.72	-8.87	54.80	0.13	56.33	0.27	3.85	0.03	13.5	0.87	0.15	0.34
TZEI114 ×IITATZSTR1159	3.06	0.33	212.0	6.58	79.8	4.11	56.33	0.86*	1.80	0.56	12.7	0.76	0.67	0.12
TZEI114 ×TZEI25	3.73	-0.08	172.60	-13.21*	78.47	-7.34	55.63	0.38	2.27	-0.72	13.6	0.86	0.23	0.07
TZEI80×TZEI188	5.03	0.18*	178.73	-9.85	75.17	-0.75	54.67	-0.63*	1.50	-0.58*	12.5	0.77	-0.43	0.87
TZEI80 ×TZSTR190	5.04	0.62*	200.53	-4.55	76.33	-2.36	56.33	0.47*	1.88	-0.01	13.1	0.87	5.22*	1.98*
TZEI80 ×TZSTR193	6.01	0.56*	167.70	7.88*	68.43	-0.53	56.00	1.58*	1.17	1.79*	13.3	0.87	2.45*	0.98*
TZEI80 ×IITATZSTR1159	5.36	0.35	166.27	-0.92	68.33	0.08	55.67	1.19*	2.52	0.61*	12.8	0.65	0.17	0.38

TZEI80 ×TZEI25	5.46	-0.19	177.00	12.84	67.13	3.31*	54.67	-0.42	1.01	-0.22	14.5	2.23	0.44	0.11
TZEI188×TZSTR190	5.04	0.06	163.50	7.62*	64.4	3.19*	56.00	-0.94	2.20	0.81*	13.1	1.28	2.06*	0.98*
TZEI188 ×TZSTR193	5.19	0.15	174.17	-2.06	62.90	-0.80	56.33	0.86*	1.16	-1.61	13.8	3.53	1.65*	2.87*
TZEI188 × IITATZSTR1159	4.07	-0.46	155.63	-3.58	65.77	-2.83	57.00	0.55	1.39	-0.42	13.9	2.33	0.76	0.21
TZEI188 ×TZEI25	5.18	0.09	170.87	-7.81	65.6	0.61*	57.00	0.63*	2.57	0.81	12.0	0.32	0.45	0.09
TZSTR190×TZSTR193	6.69	1.49*	171.03	19.38*	78.93	5.36*	58.00	2.63*	1.88	1.52*	12.9	0.27	5.64**	3.09**
TZSTR190 ×IITATZSTR1159	5.09	0.22	203.97	-5.26	79.70	-3.86	59.00	0.69	1.59	0.67*	13.6	4.12	0.55	0.12
TZSTR190×TZEI25	5.65	-0.07	-3.09	-10.96	78.03	1.42	55.00	-0.03	2.20	0.11	12.2	0.63	-0.34	0.21
TZSTR193×IITATZSTR1159	5.43	-0.39	23.46*	-2.81	65.5	0.88	56.00	0.39*	2.68	1.81*	14.0	3.54	0.46	0.09
TZSTR193×TZEI25	4.31	0.30	0.45	5.66	67.63	-3.23	55.67	0.72	2.34	0.92*	13.1	3.11	0.67	0.27
IITATZSTR1159×TZEI25	4.02	-0.02	13.52*	11.19*	65.55	2.60*	59.67	-0.20	1.77	-0.22	13.1	2.56	2.87*	1.00*

Significant at * = P < 0.05 and * * = P < 0.01 level of probability

Grain yield (t/ha), Plant height (cm), Ear height (cm), Days to silking, Ear length, NRC= Number of Rows per Cob, starch content and protein content

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CHEMICAL PROPERTIES OF CASSAVA GENOTYPES AT UNIFORM YIELD TRIAL STAGE

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ABSTRACT
Cassava is an important staple food that has boost food security and income generation over the years. It is an all purpose crop that is used traditionally and industrially. It is a remarkably known foreign exchange commodity. Processing cassava into flouris a means of adding value and expanding the use of the root crop. Cassava breeders have achieved genetic gains in improving cassava for most key agronomic attributes, but there is low adoption of these released varieties by farmers. There is the need to in cooperate food quality attributes into breeding programs so farmers, food and industrial processors can explore the potentials of these varieties Ten (10) cassava genotypes at Uniform Yield Trial (UYT) stage were harvested from NRCRI cassava programe experimental field Five (5) Kg each of the fresh roots of the different cassava clones were washed peeled grated/dewatered and processed into high quality cassava flour (HQCF). Three (3kg) of each genotype was cut into chips, dried at 50^0c and milled for laboratory analysis. The fresh roots were analysed for dry matter, crude fibre, Amylose, Amylopectin, starch and sugar content while HQCF of the genotypes were analysed for pH and total titrable acity(TTA) . The result was collected and analysed using the right statistical package. The result of the analysis obtained at UYT stage; shows the genotypes NR18059, NR16002, NR180019 and NR10018 had good chemical properties and potential attributes for confectioneries other industrial application.
Keywords: *Chemical properties, Genotypes, Amylose, pH and Total titrable acidity*

INTRODUCTION

Cassava is an important staple food that has boost food security and income generation over the years. It is an all purpose crop that is used traditionally and industrially. It is a remarkably known foreign exchange commodity. Processing cassava into flouris a means of adding value and expanding the use of the root crop. Cassava flour has been partially used to replace wheat flour in the food and plywood industries (Amoa-Awua et.al 2014,Dhingra and Jood, 2004). High quality cassava flour (HQCF) is a promising market that has gained popularity in West Africa over the past few years (Kamala et al. 2012). Cassava breeders have achieved genetic gains in improving cassava for most key agronomic attributes (Bechoff et al., 2018). The need to in cooperate food quality attributes into breeding programs has become imperative considering the low adoption of the released improved varieties by farmers, food and industrial processors respectively. Evaluating cassava varieties for different food and industrial purposes may be achieved through understanding the chemical properties of the fresh roots and their flour.

MATERIALS AND METHODS

Eight (8) cassava genotypes at Uniform yield trial (UYT) stage and two checks (TME419 and UMUCASS 46) were harvested from the experimental field of the National Roots Crops Research Institute (NRCRI) . Five (5) Kg fresh roots of the different cassava clones were washed, peeled, grated, dewatered and processed into high quality cassava flour (HCQF). 3kg of each genotype was cut into chips, dried at 50^0C and milled for laboratory analysis. The fresh roots were analyzed for dry matter and crude fibre content using the method of AOAC (2000). Amylose and Amylopectin were analysed using the method of Idowu *et al*. (2013). Starch and sugar content were determined by the spectrophotometry methods described by AOAC(2005). The PH of HQCF samples from the different genotypes were also determined using a pH meter (Model HI 98129, Hanna Instrument, Italia) The percent titrable acidity was determined following the method of FAO (2005). The result was collected and analysed using SPSS statistical package.

RESULT AND DISCUSSION

The Dry matter content ranged from 15.08 to 43.00. NR16002 had the highest dry matter content (43.00) while NR18058 had the least dry matter content , There was no significant difference($P<0.05$) between NR16002, NR18001 and NR18059. Dry matter contents relates to good cooking habit and storage quality.(Eleazu and Eleazu 2012) .The crude fibre value ranges from 0.32 to 3.27. NR18053 had the highest crude fiber content. There was no significant difference ($P>0.05$) in NR16002, UMUCASS 46, NR18059, and NR18007. The amylose content ranged from 11.35. to 25.83 with no significant difference($P>0.05$) between NR18043 and UMUCASS 46 and NR18008 and NR180018. The amylopectin content ranged from 74.17 to 88.65. There was significant difference ($p<0.05$) among all genotypes except NR18043 and UMUCASS 46, so also in NR18007 and NR180018. The starch content ranged from 23.72 to 78.51. There were no significant ($P>0.05$) between NR16002 and NR180018. The sugar content ranged from 8.86 to 16.54 with all values significantly different from each other.

The pH is an indicator of the quality of the flour, the values ranged from (5.45-6.28). There was no significant difference ($P<0.05$) in samples (NR180019 and NR180018) The pH values are less acidic. flour with pH of ≤ 4 will have a characteristics sour taste and this is not desirable in bakery products (Apea Bah *et al.*, 2011).The total titrable acid value ranged from (0.40-1.22%) were within range of value stated by National standard specification of (1.0%).

CONCLUSION

From the result of the analysis obtained at UYT stage; using rank summation index Genotypes NR18059, NR16002, NR180019 and NR10018 have good chemical properties and potential attributes for confectioneries and industrial applications.

Table 1: Chemical Properties of Fresh roots genotypes

Genotype	Dry matter%	Crude fiber %	Amylose	Amylopectin	Starch%	Sugar%
NR16002	43.00±0.57^{a}	0.69±0.02^{c}	13.68±0.43^{g}	86.32±0.04^{b}	72.26±0.08^{d}	9.65±0.08^{h}
NR18001	24.55±4.35^{cd}	0.51±0.01^{cd}	24.39±0.13^{b}	75.61±0.13^{g}	62.86±0.08^{e}	**16.54**±0.o2^{a}
TME 419	33.05±0.85^{abc}	0.32±0.21^{d}	25.83±0.00^{a}	74.17±0.00^{h}	53.35±0.08^{g}	15.49±0.02^{b}
NR18043	32.75±0.50^{abc}	0.52±0.24^{cd}	18.54±0.87^{d}	81.46±0.37^{e}	23.72±0.08^{i}	9.88±0.02^{g}
UMUCASS 46	29.30±2.40^{bc}	0.62±0.14^{c}	18.91±0.00^{d}	81.09±0.00^{e}	74.92±0.70^{c}	9.53±0.00^{i}
NR18059	37.35±1.77^{ab}	0.63^{c}±0.01^{c}	17.29±0.56^{e}	82.71±0.56^{d}	**78.51**±0.00^{a}	11.05±0.02^{e}
NR18053	15.08±0.69^{d}	3.270.38^{a}	11.350.04^{h}	88.65±0.04^{a}	52.58±0.08^{h}	13.59±0.15^{c}
NR18007	39.01±1.12^{ab}	0.790.01^{c}	14.99±0.00^{f}	85.01±0.00^{c}	54.79±0.08^{f}	10.12±0.19^{f}
NR180019	31.30±1.70.^{bc}	1.23±0.01^{b}	20.20±0.18^{c}	79.80±0.18 ^{f}	75.80±0.08^{b}	12.05±0.04^{d}
NR180018	37.20±0.00^{ab}	0.60±0.01^{cd}	15.02±0.04^{f}	84.98±0.43^{c}	72.26±0.08^{d}	8.86±0.02^{j}

Means followed by the same letter are statistically the same

Table2: Total titrable acidity value and pH of High Quality Cassava Flour

Genotypes	Ph	TTA
NR16002	5.55±0.07^{f}	0.40±0.00^{b}
NR18001	6.28±0.02^{d}	0.65±0.07^{b}
TMS419	5.9±0.12^{c}	0.70±0.00^{b}
NR18043	5.76±0.04^{e}	1.22±1.49^{a}
UMUCASS 46	6.69±0.01^{b}	0.95±050^{ab}
NR18059	6.91±0.01^{a}	0.50±0.28^{b}
NR18053	4.570.01^{i}	0.50±0.14^{b}
NR18007	5.25±0.01^{g}	0.90±0.14^{ab}
NR180019	4.95±0.05^{h}	0.65±0.21^{b}
NR180018	4.91±0.13^{h}	0.850.35^{ab}

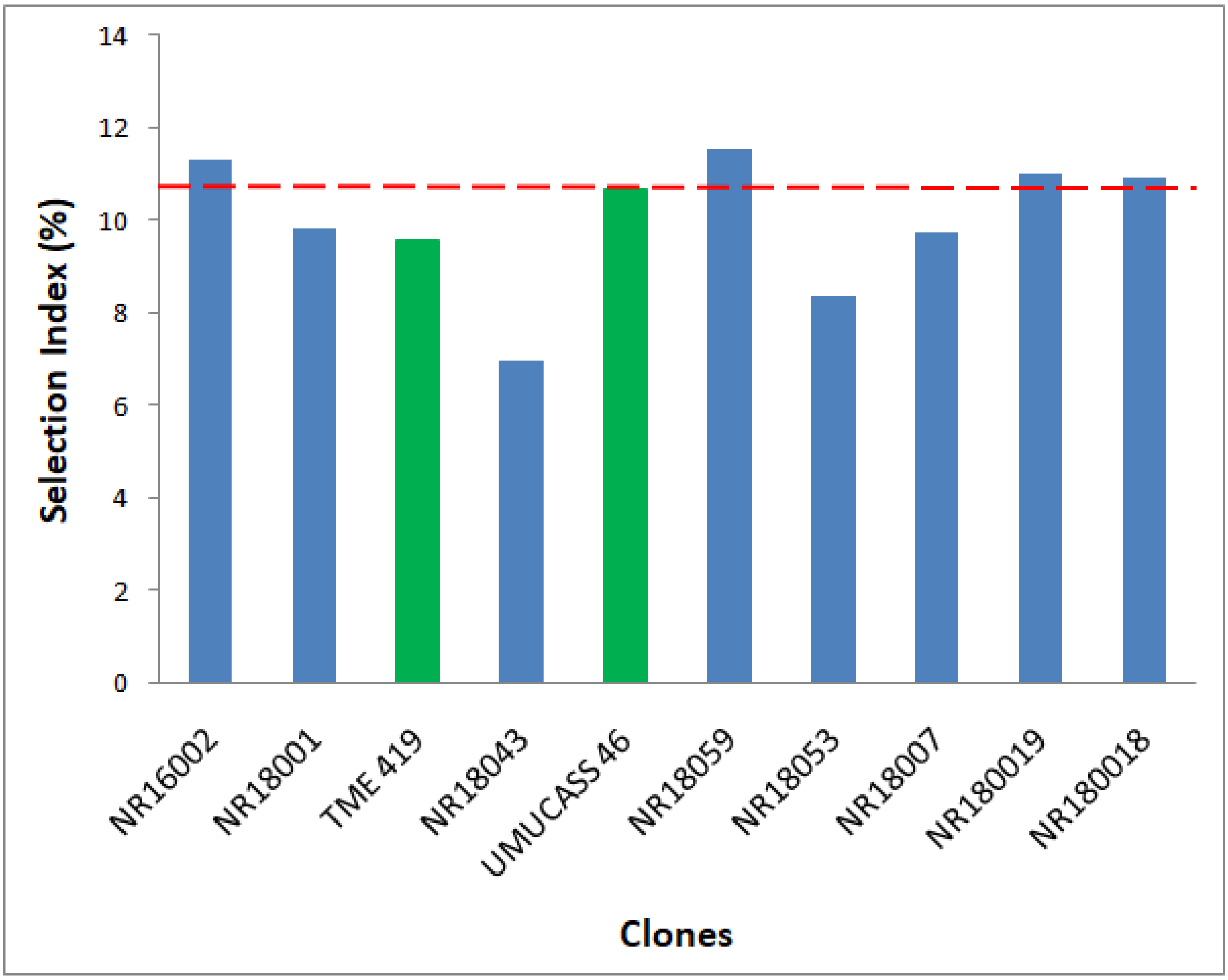

Fig 1: Graph showing the genotypes and their ranking based on their chemical properties

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QUANTITATIVE TRAIT LOCI CONTROLLING CASSAVA RETTING ABILITY AND RELATED TRAITS

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ABSTRACT

The demand gap between the breeder's crops and the consumer's choice has become a concern and necessity for adoption of improved varieties. Molecular approach has proven to be very useful in detecting solutions to complex quantitative traits driven by polygenic loci. Ability of cassava to ret (soften) fast for "fufu" processing is one of such complex traits that drives the adoption of improve varieties. In order to understand the region of the cassava genome responsible for retting ability, a molecular approach was applied using genome-wide association analysis (GWAS). One hundred and fifty-five genotypes laid in an alpha lattice design at the Experimental site of the National Root Crops Research Institute, Umudike were used for the association study. Data were collected on retting parameters using the standard operating procedure (SOP) method. The result showed low to moderate heritability estimates for the traits and significant (P<0.05) variation among the performances of the genotypes. The correlation analysis showed positive and significant coefficient of 70% between the dry matter content and firmness (penetrometer reading), while there was also a 60% positive and significant relationship between dry matter content and the retting index (fufu yield).The GWAS result indicated significant SNP markers on chromosome 2 and 10 for firmness of the root and on chromosome 16 for control of peel loss. The following vicinity functional candidate genes: LOC122723098, MANES_02G00400v8, MANES_10G043300v8, and MANES_16G013800v8 were further recognized to regulate biosynthesis of secondary metabolites for accumulation of starch and defense. Second year evaluation is in progress to further validate the result.

Keywords: *Cassava, retting ability, genome-wide association, fufu. Molecular.*

INTRODUCTION

Fufu is one of the many products that may be made from cassava, a crop that is very adaptable. A common food item made from cassava root via the retting technique is fufu, which is fermented cassava mash. Traditional fermentation of cassava that happens naturally while the roots are soaked and causes the roots to soften is known as "retting." According to Ampe *et al.* (1994), it is a crucial stage in the preparation of the majority of traditional foods made from cassava in central and West African nations. So, according to Wakem (2012), one of the key characteristics influencing consumer preference is the cassava root's ability to rotten. Similar to other food qualities, retting ability is complicated and impacted by both inherited and environmental variables. However, the role played by each component in the process of retting as well as the physiological (biophysical and biochemical) underpinnings of the root that control this qualitative feature are yet unclear Shengkui et al., (2018). Due to the lack of physiological markers on retting ability, it is challenging to incorporate this quality feature earlier in breeding programs and marker-assisted selection. As a result, the quality attributes of cassava hybrid cultivars fall short of end-user requirements and are hardly ever used. Further research is necessary, nevertheless, to determine the precise process behind these traits. Through the selection of suitable genotypes and desired phenotypic features to identify desirable functional genes or regions, molecular marker-assisted breeding is a practical method to investigate numerous advantageous allele variations Balyejusa, *et al.*, (2007). In this study, we attempt to evaluate the genetic diversity and identify the quantitative trait loci (QTL) of cassava for retting ability through the GWAS-SNP controlled by biophysical indicators associated with cassava retting of contrasted cassava varieties.

MATERIALS AND METHODS

Study area, experimental design and methods: The experiment was carried out in the experimental site of the National Root Crops Research Institute (NRCRI), Umudike. One hundred and fifty five (155) diverse cassava genotypes were established in a randomized incomplete block design (RIBD) with 2 replications.. Fresh cassava roots were processed from these genotypes into *fufu* using the validated RTBfoods standard operating protocol (SOP) for sensory characterization of *fufu* (https://doi.org/10.18167/agritrop/00595). Retting ability was also evaluated using the standard operating procedures developed within RTBfoods project**.** Instrumental firmness of 155 cassava genotypes was also measured with a handheld Penetrometer of 3.5mm diameter cylindrical probe (FHP-802 model) through fermentation time (0, 24, 48 and 72h). A total of ten (10) repeated measurement samples were taken on each genotype by measuring the proximal and distal parts of five randomly selected cassava roots per genotype through fermentation time. The turbidity of the fermented liquor was also measured in the lab using a BOSCH UV-VIS spectrophotometer (752N model). An aliquot of the fermenting liquor per fermenting vessel in two replicates was poured into a cuvette, and the transmittance was measured at 650nm.

Gene Annotation: The position of the highly significant SNP markers were explored by subjecting them to fine mapping and BLAST search on National Center for Biotechnology Information (NCBI) Genome Viewer v6.0 to annotate genomic regions and detect the nearby putative candidate genes associated with storage root formation and bulking. Putative genes within the significant SNP region were searched with respect to the significant SNPs position flanking right and left the position.

Data collections and Statistical analysis: Data were collected on the dry matter content and peel loss of the fresh root of the cassava. The methods used also entail data on the fufu yield, penetrometer readings, pH-value, turbidity and chaff loss of the fermented cassava root. A derivative summation retting index was calculated using the coefficient of the correlation of the traits to the yield by using this formula below:

Retting Index $= (X_1*W_1) + (X_2*W_2) + \ldots + (X_n*W_n)$

Where X_1, X_2, X_n *= the value of the traits under consideration, while* W_1, W_2, W_n *= economic weight with respect to the values from coefficient of correlation.*

Data were subject to analysis of variance to extract the variance components using GenSTAT v12 edition. The genome wide association study was carried out using the bioconductor package in R statistical software.

RESULTS AND DISCUSSION

Phenotypic variations and correlations of the Retting traits and Index:

The result of the analysis of variance (ANOVA) in Table 1 recorded significant ($P<0.001$) genotypic variance for all the traits indicating substantial phenotypic variance for breeders to make selection. The results also indicated that the effect of genotypes by environment interactions was not significant ($P>0.05$).

There is moderate heritability estimates observed for **penetrometer** and **turbidity (**0.653 and 0.572 respectively) from the instrumental evaluation and low heritability estimates observed for the manual (hardness: 0.279) and visual (foaming ability: 0.390; water visibility: 0.328) evaluations. The traits accompanied with moderate genetic variability confirmed that these traits are moderately genetically controlled and, selection for improvement would likely be successful. This showed that the phenotypic variance of the retting traits were better evaluated using the instrument for moderate to high genetic variation which is consistent with report by Gowda *et al.* (2015). High heritability estimates is an indication that selection of these traits should result in significant gains in cassava germplasm improvement Okogbenin *et al.* (2013).

The result of the Figure 1 showed the association of the retting traits and the index value. The results of the correlation show that strong positive and significant correlations ($P<0.001$) was observed between the bulking index and the different bulking traits like dry matter content ($r = 0.83$), and fufu yield ($r = 0.83$), but slight positive and significant correlation ($p<0.05$) with pH ($r = 0.48$). Fufu yield showed strong positive and significant correlation ($p<0.001$) with dry matter content ($r = 0.69$). The correlation of the retting index with the turbidity showed a strong negative and significant correlation ($r = -0.51$, $p<0.001$). Studies on correlation enable breeders to understand the mutual relationship among traits and indirectly consider related traits that are useful for selection, which could improve genetic values (Falconer and Mackay, 1996).

Relationship of the significant SNP marker across the retting traits: A total of three significant SNP markers passed the Bonferroni significance threshold shown in Figure 2 and 3. GWAS identified two significant SNP markers (S2_525353 and S10_4463009) for the firmness of cassava root on chromosome 2 and 10 respectively, while one significant SNP markers (S16_ 1363504) for the peel loss on chromosome 16. No significant SNP markers were observed for retting index, fufu yield and DMC. The genetic/allelic effect unit of the single SNP to the phenotypic variation was also estimated across the traits (Table 3).

Candidate Gene Annotations: Table 4 showed the number of the SNP markers related to the number of functional genes. The result recorded a total of five putative functional genes closest to the three significant SNPs of which two putative functional genes (LOC122723098 and MANES_02G00400v8) for the SNPs S2_525353 has a known gene description of mRNA-mavicyanin-like; one functional gene (MANES_10G043300v8) for the SNP marker S10_4463009 has mRNA-hypothetical protein description and two putative functional genes (MANES_16G013800v8 and LOC110603951) for the SNP marker S16_1363504 with a known gene description of Cysteine-rich receptor-like protein kinase. This putative gene (MANES_16G013800v8 and LOC110603951) were discovered to control Cysteine-rich receptor-like kinases (CRKs) which are transmembrane proteins that bind to the calcium ion to regulate stress-signaling in plant root (Quezada, *et al.,* 2019). Some of these genes have been previously identified as regulating and controlling root growth, development, and stress response in sweetpotato and related crops by Bararyenya *et al.,* (2020) and Kusaba *et al*., (2013). But this is the first time these genes were identified for retting traits.

Penet							
0.28*	C_loss						
0.20	0.65***	DMC					
0.31*	0.92***	0.69***	F_Yield				
0.58***	0.44**	0.29*	0.37**	pH			
0.08	-0.18	-0.13	-0.23*	-0.13	P_loss		
0.20	0.82***	0.83***	0.83***	0.48**	-0.24*	R_index	
0.41**	-0.33*	-0.41**	-0.26*	-0.25*	0.14	-0.51***	Turb

*, ** and *** means significant at 0.05, 0.01 and 0.001; Penet – Penetrometer, C_loss Chaff loss; DMC – Dry Matter Content; F_Yield – Fufu Yield; pH – pH value; P_loss – Peel loss; R_index – Retting index; Turb - Turbidity

Figure 1: Correlation between the retting traits and Index

Table 2: Variance component and Broad sense heritability

Statistic	Instrumental			Manual	Visual	
	Penetrometer (N)	Turbidity (NTU)	pH	Hardness	Foaming ability	Water visibility
Heritability	0.653	0.572	0.249	0.279	0.390	0.328
Genotype Variance	0.497	15.424	0.002	0.028	0.039	0.026
GenxEnv Variance	0.000	3.871	0.006	0.000	0.009	0.021
Residual Variance	1.056	37.476	0.026	0.290	0.353	0.166
Grand Mean	3.421	42.927	4.619	2.013	3.134	2.660
LSD	0.858	4.171	0.079	0.287	0.312	0.266
% CV	30.032	14.261	3.474	26.745	18.960	15.338
Genotype significance	0.001	0.000	0.277	0.029	0.050	0.020
GenxEnv significance	1.000	0.266	0.040	1.000	0.805	0.391

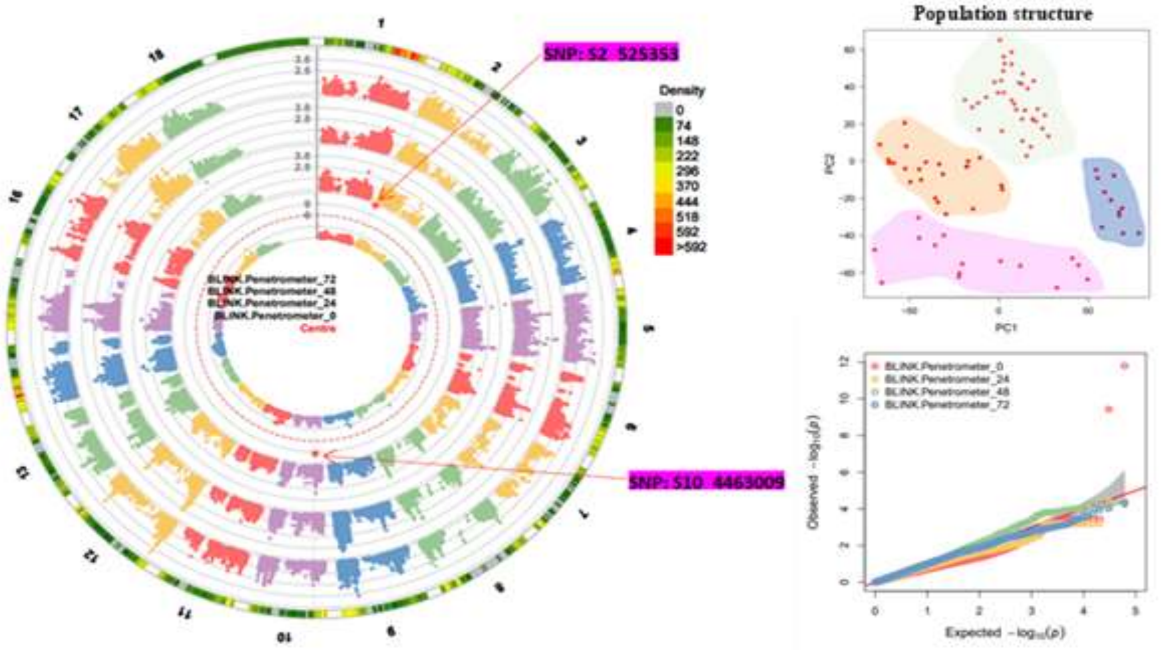

Figure 2: Circular-Manhattan plots and quantile-quantile plots for SNP significantly associated with *cassava storage root firmness (hardness) defined by penetrometer readings in BLUP data.*

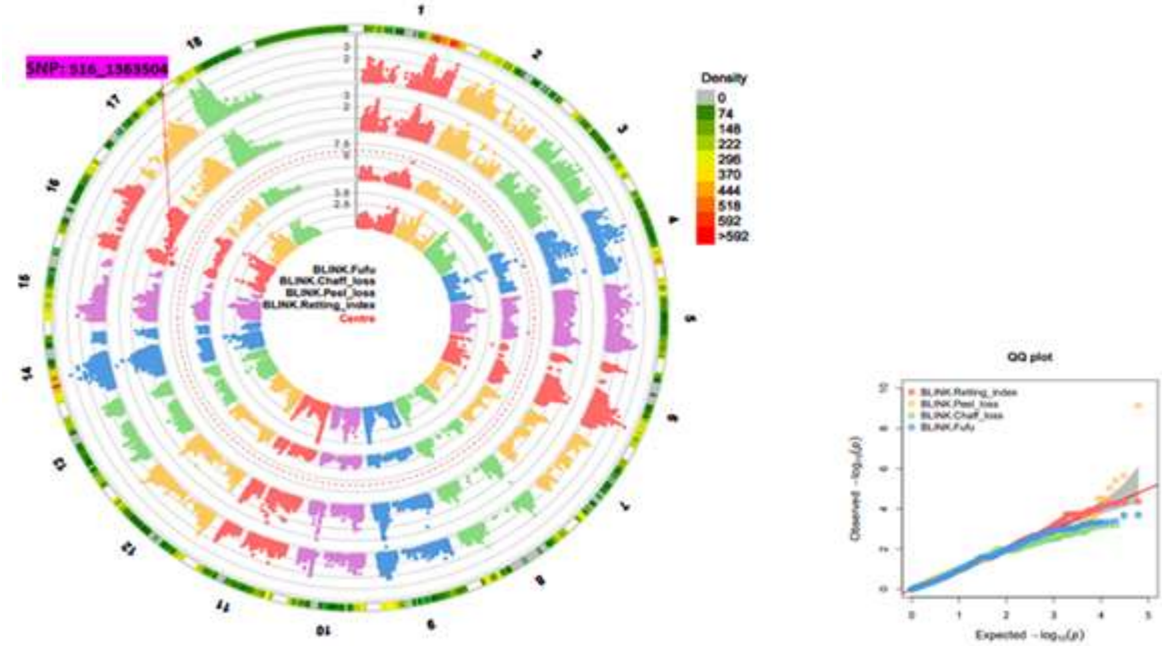

Figure 3: Circular-Manhattan plots and quantile-quantile plots for SNP significantly associated *with cassava peel loss in BLUP data*

Table 3: Significant SNP markers

SNP	Chr	Position	P.value	MAF	Traits	Effect
S2_ 525353	2	525353	1.58E-12	0.011765	Hardness	-2.59217
S10_ 4463009	10	4463009	3.68E-10	0.011765	Hardness	-2.02842
S16_ 1363504	16	1363504	7.11E-10	0.017647	Peel loss	21.24258

Table 4: Candidate Gene Discovery

SNP	Chr	Position	Traits	Gene	Gene description
				LOC122723098	mRNA-mavicyanin-like
				MANES_02G00400v8	mRNA-hypothetical protein
S10_4463009	10	4463009	Hardness	MANES_10G043300v8	mRNA-hypothetical protein
				MANES_16G013800v8	Cysteine-rich receptor-like protein kinase
				LOC110603951	Uncharacterized protein

CONCLUSION

The findings in the study showed significant genetic variations and broad sense heritability of moderate estimates for the retting traits. The SNP markers S2_ 525353 and S10_ 4463009 were found to be significant for firmness while S16_ 1363504 was found significant for peel loss. The following putative genes (LOC122723098, MANES_02G00400v8 and MANES_10G043300v8) were discovered to control mavicyanin-like protein which is related to glycoprotein isolated from zucchini peelings.

This putative gene (MANES_16G013800v8 and LOC110603951) were discovered to control Cysteine-rich receptor-like kinases (CRKs) which are transmembrane proteins that bind to the calcium ion to regulate stress-signaling in plant root.

The second year genomic studies is currently on going for the validation of this study.

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CHARACTERIZING THE RETTING ABILITY OF CASSAVA GENOTYPES USING THE HAND-HELD PENETROMETER: A MID-THROUGHPUT APPROACH FOR BREEDERS

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ABSTRACT
The need to identify cassava genotypes that meet the needs of the end-users is of great importance. A hand-held penetrometer was used to characterize 17 cassava genotypes harvested from the NRCRI Umudike UYT population and 4 varieties identified as fufu processor preferred genotypes into three main contrasting groups (high, intermediate and low retting rate) according to the rate of softening. The result showed that more genotypes retted intermediately and very few of the genotypes had low retting. This implies that a hand-held penetrometer can be used to determine the retting ability of cassava genotypes and classify them into different categories.
Keywords: *Cassava, hand-held penetrometer, retting*

INTRODUCTION
The cassava retting process is a traditional fermentation that occurs spontaneously during root soaking leading to a root's softening. It has also been reported that varietal differences have a significant influence on the extent of retting of cassava roots (Nanda et al., 1996). The degree of root softening determines the easy separation of the water-insoluble material which ultimately determines the yield of wet *fufu* mash and textural properties of fufu; traits of primary interest to *fufu* processors and consumers (Umeh et al., 2014). With the increasing demand for food due to the rapid population growth in many developing countries, local processors have resorted to the addition of various chemical substances such as kerosene, trona and common wire nails to water for the steeping of the roots to accelerate. There is therefore need for research institutes to breed and release cassava varieties that meet the needs of the end-user. However, no standard approach has been developed to be used by breeders to screen and identify genotypes that have good retting ability within the breeding population. This study aims to present the hand-held penetrometer as a mid-throughput technique for classifying or characterizing the retting ability of cassava genotypes at the early stages of breeding.

MATERIALS AND METHOD
Sample Preparation
17 different cassava genotypes from regional UYT and 4 varieties identified as fufu processor preferred genotypes were used for the retting ability studies.4kg weight of uniform-sized (medium-sized root) freshly harvested cassava roots were weighed from each genotype. The roots were peeled and 3kg of each peeled genotype was weighed into the fermenting vessel of uniform size. An equal volume of water (5 litres) was poured into each fermenting vessel containing the roots and was allowed to stand for 72 hours.

Penetration test using hand-held Penetrometer
The SOP for Determination of the Firmness of Cassava Genotypes during Retting using the Hand-held Penetrometer developed by Chijioke et al. (2023) was used. Retting progression was monitored daily by Penetration test using a hand-held penetrometer to evaluate softness. 2 penetration readings on opposite sides of five (5) randomly selected roots/genotypes were taken resulting in 10 penetration readings per genotype to evaluate firmness.

RESULTS AND DISCUSSION
Table 1 shows the retting progression concerning genotype. The result of the penetrometer data shows that retting ability is genotype-dependent. The table shows the clustering of the genotypes into 3 contrasting groups, indicating differences in the retting ability of the genotypes evaluated. More genotypes retted immediately and this includes 2 of the preferred genotypes (Nwaocha and TMEB419), followed by the high retting ones. Genotypes that had between 75-100% are classified as high retting genotypes. Some of them include NR15C1aF24P001, NR15C1aF25P001, TMS14F1306P0015 and NR15C1aF3P017. These genotypes are among those processors will

wish to adopt because they ret faster, take a shorter time to be processed and as such reduce the use of chemicals. The genotypes that had between 20-30% are low-retting genotypes. They take a longer time to ferment and won't be easily adopted by processors. This result shows that a handheld penetrometer can be used as a technique to identify cassava genotypes that have good retting ability and determine the level of firmness of crops as validated by English et al., (2022). Breeders are therefore encouraged to adopt this in screening for cassava genotypes that meet the needs of fufu processors and indigenous foods that require softening of roots.

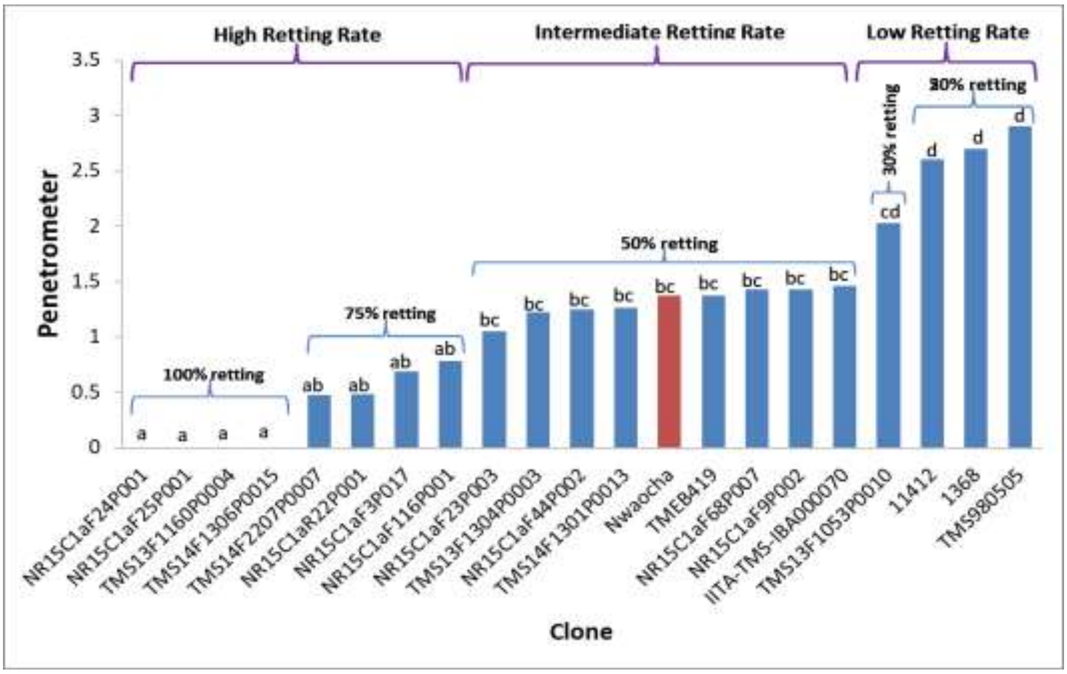

Fig. 1: Retting Progression concerning Genotypes

CONCLUSION

In conclusion, the hand-held penetrometer may be useful in discriminating between cassava genotypes as fast, intermediate or slow retting for fufu processing operations.

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"LAFIA"

SUB-THEME 6:

Land Development and Machnization Innovation for Sustainable Agriculture

SPACE LAND MANAGEMENT IN WARE YAM PRODUCTION

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ABSTRACT
Despite the economic importance of yam on lives of the people, yam faces a number of constraints that significantly reduce its potential to support rural development and meet consumers needs as an affordable nutritional product: amongst the constraints, is the availability of enough planting materials. The aim of this study is to produce ware yams in alternative soil mediums like sacks, jute bags, plastic containers and baco bags. Three yam cultivars namely: Alumaco, Hembakwase and Nwopoko were planted in Baco sacks filled with top soil. Each cultivar treated with Mancozeb and benlate (a soil insecticide and fungicide) before planting. The experiment was laid out as randomized complete block design in 6 Baco sacks/plot of 3.6m x 1m and replicated 3 times. Weeding was carried out at 4WAP, 8WAP, and 12WAP. Fertilizer N:P: K 15:15:15 was applied at the rate of 400kg/ha at 8wap. Trellis method of yam staking was carried out. Data were collected on the following: Stand count at harvest, Number of ware yams harvested, Number of seed yams, Weight/plot (kg/tons/ha) and Pests incidence. The data collected were subjected to ANOVA and significant treatment means were separated using LSD under GenStat statistical software. The result showed that there is no significant (P>0.05) difference among the different media of planting used which means that ware yams could be produced using sacks, jute bags or baco bags where land is a limiting factor. It also showed that cost of weeding could also be reduced when yams are grown in such containers. Space could as well be conserved. To get good tuber size of yam, its planting materials must be planted on a fertile medium. It is therefore recommended that due of the time and energy involved in land clearance and construction of ridges and heaps for yam planting, other energy and time saving strategy like the use of unperforated cement sacks with topsoil, dried grasses, organic manure and topsoil should be practiced and used.
Keywords: *Yam, production space management, ware yam.*

INTRODUCTION
The productivity of yam (*Dioscorea* spp.), a vegetatively propagated crop, which is cultivated for its underground edible tubers, is a very important food and income source for millions of producers, processors and consumers in West Africa. About 48mt of yams are produced annually in this sub region on 4mha of land. Nigeria is the largest producer of yams in the world contributing to two-thirds of the global yam production each year (NBS, 2013). About 32% of the population depends on yams for food and income security. Yam is the first most valuable food and agricultural commodity in Nigeria for the year 2012 (FAOSTAT, 2014); it is also integral to the socio-cultural life in this sub region. With the advancement in agriculture, various types of protected cultivation practices suitable for a specific type of agro-climatic zone have emerged. Among these protective cultivation practices, poly green house, net house, shade house, plastic tunnel, polythene bags etc. are very useful for crop production. This technology can be adopted by the rural youth for more income per unit of land. The improvement in economy of farmers with the decreasing land holding is also possible through the protected cultivation by increasing production per unit area Yam cultivation is under increasing pressure due to scarcity of planting materials, preasure on land use for agriculture, shortening of fallows, reduction in soil fertility, pests and disease build-up and rapid urbanization in most of the yam producing areas (Manyong *et al*., 2011). As a result of rapid urbanization which has claimed most agricultural lands, efforts should be geared towards producing yams using other alternative medium other than direct planting to the land (Katung *et al*., 2006). The specific objective of the study is to produce ware yams in alternative soil mediums like sacks, jute bags, plastic containers and baco bags.

MATERIALS AND METHODS
Plant materials and Experiment Design
Three yam cultivars namely: *Alumaco, Hembakwase and Nwopoko* were planted in Baco sacks filled with top soil. Each cultivar treated with Mancozeb and benlate (a soil insecticide and fungicide) before planting. The experiment was laid out as randomized complete block design (RCBD) in 6 Baco sacks/plot of 3.6m x 1m and

replicated 3 times. Weeding was carried out at 4WAP, 8WAP, and 12WAP. Fertilizer N:P:K 15:15:15 was applied at the rate of 400kg/ha at 8wap. Trellis method of yam staking was carried out. Data were collected on the following: Stand count at harvest, Number of ware yams harvested, Number of seed yams, Weight/plot in kg/tons/ha and Pests incidence . Location and period of experiment is necessary.

Data analysis

The data collected were subjected to ANOVA and significant treatment means were separated using LSD using GenSTAT statistical software.

RESULTS AND DISCUSSION

In 2011 and 2012, there was no significant difference in the mean stand count (Table 1). The mean number of ware yam in both 2011 and 2012 did not show any statistical difference. cross check your dates there was no significant difference among the treatments tested statistically within the two cropping seasons (Tables 1). However, closer observation indicated significant difference in weight among the treatment means in 2012. Treatment 1(*Alumaco*) gave the highest yield of 7.00t/h, followed by treatments 2 (*Hembamkwase*) with 4.80t/h and 3 (*Nwopoko*) with 3.67t/h respectively, However, .*Hembamkwase* and *Nwopoko* did not differ in their yields in 2011 and 2012 cropping season, there was no significant difference on the mean number of pest attack but , there was high significant difference observed in the mean number of Nematode attack(Table 2).The nematode infestation was attributed to the unsterilized soil used in the study. Similar increase in growth rate at closer spacing were noticed and reported by Rajewar *et al*. (1981) in tomato, This confirms results obtained by Sandri *et al*. (2002) , Ogbomo and Egharevba (2009) Agarwal and Zakwan (2011) in tomato, as well as Choudhary and Singh (2006)] in capsicum . The findings corroborate similar results by Busari *et al*. (2008), as well as Michael and Reid (2018), who submitted that application. inorganic manures in form of fertilizers produced the highest level of growth and yield in crops.

Table 1: Mean Stand count/No. of ware/No. of tubers and Weight/plot(tons/ha on preliminary trial on space management for ware yam production

	Yield parameters							
	2010				2011			
Treatments	**Standcount**	**No. of ware**	**No. of tubers**	**Weight/ plot**	**Standcount**	**No. of ware**	**No. of seed yams**	**weight/plot**
Alumaco	5.33	3	4	3.00	6.00	3.00	7.67	7.00
Hembamkwase	4.33	2.33	5	3.00	6.00	2.33	8.33	4.80
Nwopoko	5.33	1.33	4.67	3.33	6.00	1.33	9.33	3.67
Means	5.00	2.22	4.56	3.11	6.00	2.22	8.44	5.16
LSD(0.05)	3.069	1.772	3.421	3.023	*	1.77	4.503	3.592

Crosscheck the period of experiment.

Table 2: Mean on Pest attack on the preliminary trial on space management for ware yam production in 2011

Treatments	Cricket	Nematode
Alumaco	0.00	4.00
Hembamkwase	0.67	5.33
Nwopoko	0.33	3.00
Means	0.33	4.11
LSD(0.05)	1.309	0.756

CONCLUSION

Ware yams could be produced using sacks, jute bags or baco bags where land is a limiting factor. Cost of weeding could also be reduced when yams are grown in such containers .Space could as well be conserved. To get good tuber size of yam, its planting materials must be planted on a fertile medium. Because of the time and energy involved in land clearance and construction of ridges and heaps for yam planting, other energy and time saving strategy like the use of unperforated cement sacks with topsoil, dried grasses, organic manure and topsoil should be sought for.

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YIELD OF MAIZE (*ZEA MAYS* L.) VARIETIES AFFECTED BY PERIODS OF WEED INTERFERENCE IN GIDANKWANO (MINNA) SOUTHERN GUINEA SAVANNAH ZONE OF NIGERIA.

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ABSTRACT
Field trials were carried out at the Teaching and Research Farm of Federal University of Technology Gidan Kwano Minna, Niger State, Nigeria during 2011 and 2012 wet seasons to investigate the susceptibility of maize varieties to periods of weed interference in southern guinea savannah zone of Nigeria. The influence of varieties on the response of maize to period of weed interference was laid out in split plot design and replicated three times. The highest crop establishment percentage during 2011 wet season was observed with 2008-DTMAYSTR (77.54) and the least was Oba-98 (66.92); while during 2012 EVDTY 2000 recorded the highest value (75.02) while Oba-98 still was observe to have the least value (73.16) of the parameter through with a minimized difference with the other varieties Sammaz-13 (73.41) and 2008-DTMAYSTR (73.75). The average crop establishment percentage in 2011 was 72.92 while in 2012 it was 73.83; therefore, during 2011 the variety 2008-DTMAYSTR established best while EVDTY-2000 was best established in 2012. Among the varieties tested, 2008-DTMAYSTR was observed to have the highest average grain yield of 4.00T/ha followed by EVDT Y-2000 with an average yield of 3.40T/ha, Oba-98 3.32T/ha and Sammaz-13 3.27T/ha. The effect of variety on crop height was statistically significant at 9WAS and at harvest in 2011 and 2012 only and not the combined. The combined data revealed that the hybrid variety Oba-98 recorded the highest value of cob weight and highest weight was recorded by the Oba-98. The weed free throughout cob weight was 40.71% and 34.82% higher than the weed infested plot during 2011 and 2012 respectively. Effect of period of weed interference was significant in cob length and seed production was significant 100% seeds weight throughout the period of study. Initial weed infestation for 6 WAS only was comparable to initial weed free period for 12 WAS and till harvest. Similar to what was obtainable with the grain yield, initial weed infestation for 3WAS only did not significantly differ from plot kept weed free throughout the period of study.

Keywords: *Cob length, Cob weight, Maize varieties, Periods of weed interference, yield components***.**

INTRODUCTION
Maize is a member of the grass family, Poacea. It is the most widely adapted and was the most important cereal in the world in 2008 with production of 826.2million metric tonnes followed by rice and wheat (FAO, 2010).United States Of America was the largest producer which accounted for 37.2% of the world's total, followed by China and Brazil that accounted for 20.1% and 7.1% respectively (FAO, 2010). Africa produced 6.7% of the world's total from 29.3million hectares. Nigeria produced 7.5 million metric tonnes which represents 0.9% of the world's total in 2008; it ranks second after South Africa in the African continent.

Maize production in Nigeria was initially restricted mainly to the forest zone but the production has now expanded to the savannah where it accounts for over 70% of the production in the country (Uyovbisere *et al.*, 2001). Kassam *et al.*, 1975 attributed the higher production of the crop in the savannah to more favourable production conditions which includes solar radiation intensities, lower night temperature and low incidence of diseases and pests. Maize was introduced into Nigeria probably in the 15th century by Portuguese (Osagie and Eka, 1998). The country`s maize crop covers about 1million hectare out of 9 million hectares it occupied in Africa (Hartman, 1985). Maize is a cereal plant that produces grains that can be cooked, roasted, fried, ground, pounded or crushed to prepare various food items like pap, tuwo, gwate, donkunu and a host of others (Abdur Rahman and Kolawole, 2006).

Hoeing is the cultural method adopted for weed control in cereals of which maize is inclusive in the southern guinea savannah zone. It is labourious, slow, expensive and only feasible on a small holding (Lagoke.1988; Adeosun, 1990). Some weeds especially those that have close resemblance with the maize crop at the young stage e.g. *Andropogongayanus* may however escape weeding; these will compete maize seriously and will cause reduction in yield considerably. Hoe weeding is beneficial to the maize crop because it tends to improve aeration in the soil environment. For the hoe weeding to be successful, Proper timing and frequency of weeding are necessary. The broad objective of this study is to assess four maize varieties to ten periods of weed interference.

MATERIALS AND METHODS

Field trials were conducted during the raining season of 2011 and 2012 on the research farm of the Federal University of Technology Gidankwano Minna (situated on Longitude 6.23^{0}E, Lattitude9.37^{0}N and altitude of 1475m above sea level) in the Southern Guinea Savannah zone in Niger State of Nigeria. The treatments were laid out split plot design. These were made into maize varieties (early, extra early and a late maturing or hybrid) and ten periods of weed interference. One set of the interference treatment, plots were kept initially weed free for 3, 6, 9 and 12 weeks after sowing (WAS) maize and subsequently left not weeded. In the other set of treatments, plots were left unwedded for 3, 6, 9 and 12 WAS but were left weed free until harvest. Two control treatments were maintained in which one plot was weed free while the other plot weed infested until harvest in both cases for the purpose of comparison. The treatment consisted of 2 early maize variety one extra early variety and one hybrid. The plot size was 1800m^2 with ten rows separated at 50cm. four crop varieties of maize were used, Oba 98 hybrid maize matures in 100-120 days and is excellent drought escape variety, its grain is white in colour and it is labelled as $V_{1,}$ SAMMAZ 13 (Extra early variety) maize matures in less than 80 days and is excellent drought escape variety, its grain is yellow in colour and labelled as V_2, EVDT – Y2000 (Early variety) striga tolerant, matures in less than 90 days drought tolerant and can be grown in soils that have low Nitrogen. Its grain is yellow in colour labelled as $V_{3,}$ 2008 DTMAYSTR (Extra early variety) striga tolerant, matures in less than 90 days drought tolerant and can be grown in soils that have low Nitrogen. Its grain is yellow in colour it is labelled as $V_{4.}$ These shall be obtained from the seed production unit of the Institute for Agricultural Research Ahmadu Bello University Zaria.

The experimental area was cleared, ridged and spaced at 75cm. The field was marked out into plots and replications. Each split plot had six ridges with a measurement of 4m x 3.75m. There was a total of 120 split plots on the field separated by an unplanted border of 50cm. The seeds were sown manually at the rate of 3 seeds per hole along the ridges using an intra-rows spacing of 50cm. The plants were thinned to 2 plants per stand at ten days after planting. Cultural weeding using hoe was carried out at 3, 6, 9 and 12 WAS for both cultivation season of 2011 and 2012. Basal application of fertilizer using NPK 15-15-15 was done after 2 WAS at 600g/plot and top dressed with urea after 4-5 WAS at the rate of 200g/plot by banding method.

The observations and data collection was done on crop establishment and grain yield ha^{-1} (tons) and was statistically analyzed.

RESULTS

Crop establishment: The effect of variety and period of weed interference on maize crop establishment percentage at harvest during 2011 & 2012 wet seasons is presented in Table 1. Variety did not significantly affect crop establishment in 2012 but in 2011 and the combined. Variety 2008-DTMAYSTR exhibited higher establishment percent than Oba-98 in both years and the combined (Table 1). Period of weed interference significantly affected crop establishment percentage in both years, and the combined (Table 1).The percentage establishment was observed to decrease as plots were kept unweeded after 6WAS, till harvest during 2011 and after 3WAS till harvest in 2012 wet seasons and combined. Conversely the percentage crop establishment was observed to increase to a maximum value when plots were kept weed- free initially from 3WAS till harvest. The crop establishment percentage was observed to be higher during 2012 wet season than 2011. However, keeping the crop initially weed infested for 3WAS did not differ significantly from those kept weed free for 12WAS. In 2011 and combined and those kept weed free till harvest in 2012 (Table 1), There was no significant interaction between the variety and period of weed interference in crop establishment throughout the period of study.

Table 1 Effects of Variety and periods of Weed- interference on percentage crop establishment at harvest at Gidan kwano for 2011 and 2012 wet seasons

Treatment	Crop establishment at harvest 2011	2012	combined
Variety			
Oba-98	66.92b	73.16	70.04b
Sammaz-13	73.26ab	73.41	73.34ab
EVDTY-2000	73.47ab	75.02	74.25ab
2008DTMA YSTR	77.54a	73.75	75.65a
SE±	**0.70**	**NS[3]**	**0.43**
Period of weed interference			
Weed infested for 3WAS[1]	85.31a	86.04b	85.68
Weed infested for 6WAS	82.90a[2]	74.48d	78.69bc
Weed infested for 9WAS	75.70ab	67.54f	71.62de
Weed infested for 12WAS	64.24bc	60.32g	62.28f
Weed infested till harvest	29.69d	36.95h	33.32g
Weed free for 3WAS	59.29c	71.19e	65.24ef
Weed free for 6WAS	73.94ab	79.09c	76.52cd
Weed free for 9WAS	84.03a	85.05b	84.54ab
Weed free for 12WAS	85.62a	86.34b	85.98a
Weed free till harvest	87.24a	91.37a	89.31a
SE±	**4.40**	**1.08**	**2.29**
Interaction (VxW)			

1 Week after sowing.
2. Means followed by the same letter (s) / are not significantly different at 5% level of probability (DMRT)
3 NS Non significant
4 Treatment not applied.

Table 2 result shows that the effect of variety on grain yield was significant only in 2011. Variety 2008-DTMA-YSTR was observed to have the highest grain yield in 2011 with a value of 3.77t/ha (Table 2) followed by Sammaz-13(2.71t/ha), next is EVDT Y-2000 (2.57t/ha) and Oba-98(2.25t/ha) had the least grain yield value during the 2011 wet season. Although not significant the yield in 2012 was more than that of 2011.
Period of weed interference significantly affected grain yield throughout periods of the study and the combine. The grain yield was observed to decrease as plots were kept initially weed infested from 3WAS till harvest during 2011 and 2012 wet seasons and the combined. As the plots were initially kept weed free the grain yield was observed to increase from a minimum value of 1.69t/ha 2.73t/ha and 2.36t/ha respectively for 2011, 2012 are combined to a maximum value of 3.87t/ha 6.47t/ha and 5.17t/ha respectively from 2011, 2012 and combined (Table 2) hence showing that weeds interfere or deplete nutrients from the soil rendering it unavailable to crop plants. Weed infestation for 3WAS did not significantly affect the grain yield throughout the study and the combined compared with weed free from 9WAS and till harvest. However infestation beyond 6WAS drastically reduced the grain yield compared with the initial weed free periods from 9WAS till harvest. Similarly initial weed free period for 3 weeks only did not differ significantly from plots kept weedy throughout the period of study.

Table 2 Effect of Variety and Periods of weed- interference on grain yield at Gidan Kwano for 2011 and 2012 wet seasons.

Treatment	**Grain yield (T/ha) 2011**	**2012**	**combined**
Variety			
Oba-98	2.25b	4.38	3.31
Sammaz-13	2.71b	3.83	3.27
EVDT-Y2000	2.57b	4.23	3.40
2008DTMA-YSTR	3.77a	4.23	4.00
SE ±	**0.21**	**0.25**	**0.20**
Period of weed-interference			
Weed Infested for 3WAS[1]	3.57a	5.95a[2]	4.76a
Weed Infested for 6WAS	2.51bc	4.63bc	3.57cd
Weed Infested for 9WAS	2.40bc	3.93dc	3.17ed
Weed Infested for 12WAS	1.69c	2.97e	2.27ef
Weed Infested till harvest	1.57c	1.79e	1.74f

Weed free for 3WAS	1.69c	2.73de	2.36ef
Weed free for 6WAS	2.00c	3.53dc	3.45d
Weed free for 9WAS	3.59a	4.25bc	3.96bcd
Weed free for 12WAS	3.67a	5.41ab	4.50abc
Weed free till harvest	3.87a	6.47a	5.17a
SE±	**0.33**	**0.41**	**0.32**
Interaction (VxW)	**NS**	**NS**	**NS[3]**

1WAS - week after sowing.
2. Means followed by the same letter (s) / are not significantly different at 5% level of probability (DMRT)
3 NS non-significant

Treatment Interaction shows that the result of the combined analysis showed that maximum grain yield was obtained with plots kept weed free from 6WAS and till harvest with 2008-DTMAYSTR as well as the least grain yields on weed infested plot till harvest with Sammaz-13 during 2011 wet season. This clearly showed the variation in the ability of the varieties to compete with weed and to produce an acceptable grain yield. Although the maize variety EVDTY-2000 when kept weed free for 6WAS had comparable crop vigour to the maximum while Oba-98 kept weed infested for only 6WAS had the least comparable vigour score. This might be due to the fact that crops kept weed free had the benefits of utilizing both underground and above ground nutrients. Ayeni and Duke (2011), earlier reported that good crop vigour influence and enhance good development of the photosynthetic capacity, prior to tasselling initiation and grain filling in maize crop as a result of better utilization of available growth resources in the absence of weeds.

DISCUSSION

Weed infestation throughout the crop life-cycle decreased the yield of maize variety Oba-98 by 65 and 50% in 2011 and subsequently other yield parameters were observed to reduce. Similar yield reductions between 50 and 87% of maize due to uncontrolled weeds throughout the crop life-cycle was reported by (Kunjo, 2011). Period of weed interference also had significant effect on crop vigour score at 9WAS during 2012 wet season. Keeping plots weed free till 9WAS and beyond produced more vigorous crops, while keeping crops weed infested and beyond for similar periods, produced less vigorous crops. This might be due to the competition for growth factors between the maize and the weeds in the weed infested plots as reported by IITA (2007). Plant height was significantly affected at 9WAS and at harvest for both years. While keeping plots weed free till 9WAS and beyond produced taller crops, the converse is the case when plots are weed infested for the same period. Carson (2010) stated that when maize crops are kept weed infested for 9WAS and beyond their heights significantly decrease. Other yield parameters such as maize cob weight, cob length and weight of 100 seeds were all significantly affected by period of weed interference. Weed infestation from 6WAS and till harvest significantly decreases these yield parameters. In the study, uncontrolled weeds throughout the life cycle of maize varieties resulted in grain yield loss of 59.43% and 72.33% respectively for 2011 and 2012 wet seasons compared to maximum obtained with weed free plots throughout the study. Weed infestation for 3WAS only did not significantly affect grain yield of maize in 2011 compared with initial weed free plots at 9WAS while weed infestation for 3WAS only was comparable to initial weed free plots up to 9WAS.
It is apparent that once the crop was kept weed free for 12WAS subsequent weed infestation until harvest did not cause any significant reduction in maize grain yield in the four varieties. Contrary to earlier reports, weeds infestation for first 3WAS caused significant reduction in maize grain yield, even though it did not have adverse effect on crop growth as reflected in crop vigour score, crop height and weed dry matter production. The yield depression by weed infestation for 3WAS may be attributed to rapid weed growth and its high infestation within 3WAS during the growing season. This was apparent in the weed cover score at 9WAS and beyond. Weed infestation with crop until 12WAS resulted in significantly lower crop vigour score and grain yield compared infestation for 3WAS. Subsequent weed removal until 12WAS did not prevent reduction in grain yield compared with weed infestation until harvest. Weed dry matter production was higher during 2011 than 2012.

CONCLUSION

A significant maize grain yield reductions were recorded when weeds were associated with maize varieties for 6WAS and more. In the study, uncontrolled weeds throughout the life cycle of maize varieties resulted in grain yield loss of 59.43% and 72.33% respectively during 2011 and 2012 wet seasons compared to maximum obtained with weed free plots throughout the study. Weed infestation for 3WAS only did not significantly affect grain yield of maize in 2011 compared with initial weed free plots while weed infestation for 3WAS only was comparable to initial weed free plots up to 9WAS.

RECOMMENDATION

It is recommended that a weed free period of 21-42days after planting is required for an acceptable maize grain yield with 2008-DTMAYSTR and EVDTY-2000.

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ENHANCING SUSTAINABLE AGRICULTURE THROUGH LEGUME-CEREAL CROP ROTATIONS IN NIGERIA (A REVIEW)

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ABSTRACT

The paper aims to examine the historical significance of crop rotation as an agricultural practice, particularly in Nigeria, and elucidate its potential benefits in mitigating soil erosion, enhancing water utilization efficiency, and sustaining high crop yields. Crop rotation, a time-honored agricultural practice celebrated for its historical yield advantages, entails cultivating a variety of crop types sequentially within the same area over successive seasons. Nigeria, steeped in agricultural tradition, has embraced rotation cropping systems for numerous years. Given the pronounced climatic and soil diversities across different Nigerian regions, cropping practices exhibit considerable variations. The investigation into the impacts of legume-cereal crop rotation on crop yields boasts a long-standing history, with contemporary literature supporting the assertion that soybean-corn crop rotation yields increased grain production and represents an avenue for sustainable agriculture. Comprehending alterations in soil physical, chemical, and biological characteristics is paramount for elucidating the mechanisms responsible for both the direct and indirect effects of crop rotation on grain yields, along with its environmental benefits. This paper undertakes the task of assembling and synthesizing existing literature pertaining to diverse legume-cereal crop rotation studies conducted across various agroecological regions of Nigeria. The attainment of sustainable production and the effective implementation of legume-cereal crop rotations in a site-specific context hinge on an array of factors. These factors encompass crop composition, varietal selection, conservation tillage practices, and integrated pest and weed management approaches, necessitating collaborative efforts across multiple disciplines and sectors. Consequently, the introduction and adoption of new cropping systems and technologies must undergo rigorous testing under site-specific conditions and gradual dissemination, transitioning from initial demonstration plots to wider regional adoption.

Keywords: *Crop rotation, legume-cereal, sustainable agriculture, Nigeria, soil properties, site-specific adoption*.

INTRODUCTION

Crop rotation involves cultivating a variety of crop species successively on the same piece of land, as highlighted by several authors (Yates, 1954; Shen and Liu, 1983). This stands in contrast to intercropping, where multiple crops are grown simultaneously on the same land, as noted by Stinner and Blair (1990), or continuous monoculture, which entails repetitive cultivation of a single species on the same land, as described by Power (1990). Extensive research has consistently demonstrated the efficacy of crop rotation in mitigating soil erosion, enhancing water utilization efficiency, and sustaining high crop yields, as emphasized by Zhu et al. (1994) and Li et al. (2000).

In the context of this chapter, we place particular emphasis on the primary forms of crop rotation practiced in Nigeria, with a specific focus on legume-cereal crop rotations. Crop rotation may involve the sequential cultivation of two or more crops over multiple growing seasons. For instance, a two-crop rotation, such as alternating between Maize (Zea mays) and soybean (Glycine max) or guinea corn (Sorghum bicolor) and peanut (Arachis hypogaea) in alternating years, exploits the leguminous crop to supply complementary inorganic nitrogen to the soil for subsequent crops. Legumes have long been recognized as "soil-building crops" due to their ability to significantly enhance the biological, physical, and chemical properties of the soil when cultivated. Therefore, from an agricultural standpoint, it is sensible to intersperse them with cereals and other nitrogen-demanding crops. The positive effects of crop rotation on crop yields have been consistently reported by numerous scientists over the years, as evidenced by Bullock (1992), Carsky et al. (1997), Fan et al. (2012), Kelley et al. (2003), and Yusuf et al. (2009). In the legume-cereal rotation system, this beneficial effect is attributed to the availability of additional nitrogen (N) resulting from biological nitrogen fixation and other rotational influences, as discussed by Sanginga et al. (2002). Legume-cereal rotation enhances soil nutrient content, with legumes possessing root nodules that harbor nitrogen-fixing bacteria called rhizobia, as pointed out by Danga et al. (2009). The inclusion of grain legumes in rotation with annual cereal crops contributes to the overall nitrogen pool in the soil and enhances cereal yields.

Crop rotation systems optimize the utilization of soil resources, including nutrients, water, and biodiversity, by cyclically switching between different crops over consecutive years, capitalizing on their varying characteristics. This approach not only fosters crop production and land utilization efficiency, as advocated by Bullock (1992), but also offers farmers a means to maintain continuous field productivity, reducing the need for chemical fertilizers. Furthermore, crop rotation has the added benefit of diversifying the geographical distribution of crops. The objective of this review paper is to comprehensively assess and synthesize existing literature on the practice of legume-cereal crop rotation, with a specific focus on its impact on crop yields, soil properties, and sustainability in diverse agroecological regions of Nigeria.

Crop Rotational as a Sustainable Agricultural Practice

Crop rotation is a time-tested agricultural practice with a history deeply rooted in sustainable agriculture (Yates, 1954). This age-old technique involves systematically altering the types of crops cultivated on the same land over consecutive growing seasons. Its primary objective is to maximize soil resources, minimize soil depletion, and mitigate disease buildup, making it a cornerstone of sustainable farming.

Yates (1954) underscores the historical importance of crop rotation as a means to enhance soil health and agricultural sustainability. This practice has been honed over centuries to optimize crop yields while preserving the long-term productivity of the land. It involves strategic planning to ensure that the crops selected for rotation complement each other in terms of nutrient requirements and pest management.

In Nigeria, an agriculturally rich nation deeply entrenched in farming traditions, crop rotation has evolved over the years to suit the diverse agroecological regions (Shen and Liu, 1983). Nigeria's agricultural history is characterized by a tapestry of innovative farming practices, many of which emphasize sustainable land management and food production. The country's agricultural landscape spans a wide range of climatic zones and soil types, resulting in a plethora of cropping practices across different regions.

Shen and Liu (1983) discuss the adaptation of crop rotation practices to Nigeria's diverse agroecological regions, highlighting the nation's commitment to optimizing agricultural sustainability. These adaptations have been crucial in addressing the unique challenges posed by the country's multifaceted agricultural sector.

Research studies consistently affirm the positive impact of legume-cereal crop rotations on critical aspects of agriculture, including crop yields, soil properties, and overall sustainability (Bullock, 1992; Carsky *et al*., 1997; Fan *et al.*, 2012). This positive effect is primarily attributed to the nitrogen-fixing capacity of legumes, which enrich the soil with essential nutrients through their symbiotic relationship with nitrogen-fixing bacteria known as rhizobia (Sanginga *et al*., 2002).

Bullock (1992), in their research, provides evidence of the significant improvements in crop yields achieved through legume-cereal crop rotations, supporting the notion of enhanced agricultural sustainability. Carsky et al. (1997) delve into the impact of legume-cereal rotations on crop yields, particularly in the context of West Africa, shedding light on the practical benefits of this practice.

Fan et al. (2012) conduct a study on sustainable crop rotations, emphasizing the role of legume-cereal rotations in improving soil fertility and, by extension, crop sustainability. Furthermore, legume-cereal crop rotations have been shown to conserve soil structure and organic matter, contributing to overall soil health (Kelley *et al*., 2003). This dual benefit not only bolsters crop production but also aligns with the principles of sustainable agriculture by reducing soil erosion and preserving the long-term productivity of farming systems.

Mitigating Soil Erosion and Enhancing Water Use Efficiency

Crop rotation's role in mitigating soil erosion is well-established, as evidenced by Zhu et al. (1994), who recognize its pivotal role in sustainable agriculture. Soil erosion, characterized by the loss of topsoil due to natural forces like wind and water, poses a grave threat to soil fertility and overall agricultural productivity. Nigeria, with its diverse climate and soil types, necessitates an adaptable and region-specific approach to cropping practices, as highlighted by Li *et al*. (2000). In Nigeria's agricultural landscape, characterized by varying agroecological zones experiencing diverse rainfall patterns and soil characteristics, the significance of crop rotation in controlling soil erosion becomes paramount.

Crop rotation effectively reduces soil erosion in Nigeria through several well-documented mechanisms:

Root Structure and Soil Stability

Crop rotation with a mix of deep-rooted and shallow-rooted crops, such as legumes with robust root systems, enhances soil stability. Deep-rooted crops create channels in the soil that facilitate water infiltration and reduce surface runoff, as noted by Hargrove (2001).

Residue Cover

Crop residues left on the field post-harvest act as a protective cover against soil erosion. By varying crops in rotation, the quantity and quality of residue cover can be optimized, aiding in the reduction of erosion rates, as highlighted by Mann (1986).

Diverse Canopy Architecture

Crop rotation often involves cultivating crops with varying canopy structures. Tall crops can intercept rainfall and reduce the impact of water droplets on the soil surface, a crucial factor in erosion mitigation, as discussed by Zhang et al. (2002).

Soil Microbial Activity

Crop rotation influences soil microbial communities, with different crops releasing distinct exudates and root exudates that impact soil structure and microbial activity. These microbial communities play a vital role in stabilizing soil aggregates and minimizing erosion, as explored by Hartmann et al. (2015).

These empirical studies collectively emphasize how crop rotation, tailored to Nigeria's diverse agroecological characteristics, serves as a powerful tool in combating soil erosion, safeguarding soil fertility, and optimizing water use efficiency. This approach not only ensures the long-term sustainability of agricultural lands but also aligns with sustainable farming practices.

Mechanisms of Positive Effects and Role of Crop Composition and Varietal Selection

One of the fundamental mechanisms underlying the positive impacts of legume-cereal crop rotation is nitrogen fixation by legumes. Numerous empirical studies confirm the substantial contribution of legumes to soil nitrogen levels. For example, a study by Sanginga *et al.* (2002) conducted in West Africa demonstrated that grain legumes in rotation with cereals significantly increased the total nitrogen pool in the soil, consequently benefiting cereal crop yields. Changes in soil physical, chemical, and biological properties resulting from legume-cereal crop rotations have been widely documented. Danga et al. (2009) conducted research highlighting the improvement in soil health due to crop rotation. Their study revealed that legumes, with their root nodules housing nitrogen-fixing rhizobia bacteria, positively influence soil microbial communities, which, in turn, enhance nutrient cycling and soil structure.

Empirical studies have underscored the significance of crop combinations in crop rotation systems. For instance, research by Carsky et al. (1997) in West Africa explored the impact of specific legume-cereal combinations on crop productivity. They found that certain combinations, such as cowpea and maize, had synergistic effects on soil fertility and crop yields, emphasizing the importance of strategic crop composition within rotations. Varied crop varieties within the same species can exhibit different growth patterns, disease resistance, and adaptability to local conditions. A study by Fan et al. (2012) in North China Plain assessed the impact of varietal selection in wheat-maize rotations. They discovered that the choice of wheat and maize varieties significantly influenced yield outcomes and nutrient utilization efficiency. This empirical evidence underscores the importance of selecting crop varieties tailored to specific agroecological zones.

Conservation Tillage and Integrated Pest Management (IPM)

Empirical studies have consistently shown the benefits of conservation tillage practices within legume-cereal rotation systems. Research by Derpsch et al. (2010) conducted in various countries, including Nigeria, demonstrated that no-tillage and reduced tillage practices help improve soil structure, moisture retention, and reduce erosion. Such practices, when integrated into crop rotations, contribute to both higher yields and enhanced environmental sustainability. In addition to conservation tillage, Integrated Pest management (IPM) strategies are integral to sustainable crop rotation systems. A study by Ogunlade et al. (2017) in Nigeria's maize-legume cropping system highlighted the effectiveness of IPM in controlling pests and reducing the need for chemical pesticides. By strategically incorporating pest-resistant crop varieties and biological control methods, IPM contributes to higher crop yields and reduced environmental impact.

The importance of site-specific testing in crop rotation systems has been well-documented. A study by Ndiiri et al. (2016) in Kenya emphasized the significance of adapting cropping systems to local conditions. Their research revealed that site-specific testing and tailored crop selection led to increased yields and enhanced sustainability. This empirical evidence underscores the need to consider agroecological factors when implementing crop rotations. Every site-specific testing in crop rotation should be succeeded by Technology dissemination. Gradual technology dissemination is crucial for the successful adoption of crop rotation practices. An investigation by Akinseye et al. (2016) in Nigeria emphasized the importance of extending successful practices beyond demonstration plots to wider regional adoption. Their study demonstrated that farmer-to-farmer knowledge sharing and community-based extension services were effective in disseminating crop rotation techniques, leading to increased yields and sustainability.

CONCLUSION

Crop rotation, a time-honored agricultural practice, plays a pivotal role in sustainable agriculture, as highlighted by a wealth of empirical research spanning several decades. This practice involves the systematic rotation of different crop species on the same land over successive seasons, with the primary goal of optimizing soil resources, minimizing soil depletion, and mitigating disease buildup. In this context, we placed particular emphasis on legume-cereal crop rotations in Nigeria. In conclusion, crop rotation, particularly legume-cereal crop rotations, stands as a cornerstone of sustainable agricultural practices in Nigeria and beyond. Empirical research consistently validates its efficacy in improving crop yields, enhancing soil health, and mitigating environmental challenges. Implementing and further refining these practices in diverse agroecological regions is essential for ensuring food security, preserving soil fertility, and fostering sustainable agriculture in the face of evolving agricultural landscapes and global challenges.

RECOMMENDATIONS

Based on the empirical evidence presented regarding the significance of crop rotation, particularly legume-cereal crop rotations, in sustainable agriculture, the following recommendations are proposed:

I. There is need to collaborate with government agencies, agricultural extension services, and NGOs to raise awareness among farmers about the benefits of crop rotation.
II. Conduct training programs, workshops, and educational campaigns to disseminate knowledge and best practices.
III. Motivate farmers to develop site-specific crop rotation plans tailored to their region's agroecological characteristics. This should consider factors such as local climate, soil types, and prevalent crop diseases to optimize rotations.
IV. Invest in research initiatives focused on refining crop rotation systems, particularly those involving legume-cereal combinations.
V. There is need to promote the integration of IPM strategies into crop rotation systems. This includes identifying pest-resistant crop varieties, implementing biological control methods, and reducing reliance on chemical pesticides to minimize environmental impact.

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FERTILITY STATUS OF ORCHARD SOILS AT THE INSTITUTE FOR AGRICULTURAL RESEARCH HORTICULTURAL ORCHARD

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ABSTRACT
The continuous cultivation of land has led to a decline in soil fertility, which poses a significant challenge of food insecurity in developing countries. To assess this issue, a study was conducted to evaluate the physical and chemical properties of soil samples collected from two profiles. The results showed low levels of organic carbon (ranging from 0.80 to 9.20 g kg^{-1}), available nitrogen (ranging from 0.10 to 1.15 g kg^{-1}), and available phosphorus (ranging from 2.98 to 5.95 mg kg^{-1}). The soil samples were moderate to slightly acid, with pH values ranging from 4.60 to 6.40. In addition the cation exchange capacity of the soil was found to be medium, ranging from 5.70 to 9.60cmol kg^{-1}. Furthermore, the Exchangeable Sodium Percentage (ESP) indicated that the soil quality was excellent. From the result of this study it is evident that the nutrient status of the orchard soils is inadequate. The following management practices are suggested, the application of organic manure, nitrogenous and phosphorus fertilizers. These practices will help improve the soil's nutrient content and fertility status, ultimately contributing to robust agricultural productivity and addressing the problem of food insecurity in developing countries.
Keywords: *Soil profile, Exchangeable Sodium Percentage (ESP), orchard, nutrient status.*

INTRODUCTION
Fertility status of soil plays a crucial role in orchard plantation. When crops are continuously cultivated in an orchard, the fertility status of the soil can improve within the root zone depth, considering that lime and phosphorus have limited mobility while potassium moves slowly. Sofo *et al*. (2020) submitted that in many orchard soils, soil biodiversity and the ecosystem services it provides are under threat from a range of natural and man-made drivers. Kurešová *et al*. (2019) highlighted the importance of understanding the nutrient status of orchard; therefore, assessing soil fertility is a fundamental tool for making sustainable decisions regarding soil nutrient management. This evaluation involves measuring the availability of essential nutrients for plants and estimating the soil's capacity to provide a continuous supply of nutrients to crops. Soil properties exhibit spatial and temporal variations, ranging from individual fields to larger regional scales, influenced by both intrinsic factors (e.g., soil parent materials) and extrinsic factors (e.g., soil management practices, fertilization, and crop rotation). Soil fertility significantly impacts crop yield and productivity, with nutrient deficiencies being a major constraint to soil sustainability and productivity (Kumar *et al*., 2020). Despite continuous cultivation, little attention has been given to maintaining soil fertility in the soils of the Institute for Agricultural Research (IAR) orchard. In addition the locally available data on soil fertility status are insufficient. Therefore, the objective of this research is to investigate the current fertility status of the orchard soil.

METHODOLOGY
The Study area
This research was conducted at the orchard of the Institute for Agricultural Research (IAR) in Samaru, Kaduna State, Nigeria. The experiment site is situated at coordinates 11° 10.37.0'N latitude and 7° 37.88.1'E longitude, with an altitude of 698 meters above sea level. The location falls within the northern guinea savanna ecological zone of Nigeria. The climate in this region is classified as sub-humid tropical, characterized by distinct wet and dry seasons. The orchard covers an area of 6.41 hectares and cultivates a variety of fruits and agricultural crops. Among the fruit trees grown in the orchard are guava, mango, cashew, grapevine, pawpaw, coconut, apple, oil palm, jackfruit, avocado pear, custard apple, kola nut, cocoa, coffee, orange, banana, and others.

Fruit trees, when properly planted with suitable soil and other considerations, can live for many years in an orchard (Ahmet, 2009). The orchard also includes other fruit trees like apple, oil palm, and cocoa, which are not the primary focus of the Institute. This demonstrates the Institute's commitment to conducting broader research (Shobayo *et al*., 2019). The orchard is well-organized and divided into sections for the nursery and permanent plots dedicated to specific tree species.

Field Observation

Two profile pits were randomly excavated within IAR horticultural orchard, and a total of seven soil samples were gathered from genetic layers of the soil to assess its characteristics. In addition, bulk soil samples were obtained from each genetic layer for further analysis in the laboratory. Core samples were extracted to determine the bulk density.

Laboratory analysis

The bulk soil samples collected from each layer were subjected to a series of procedures. First, they were air dried and then ground and sieved to eliminate particles larger than 2 mm in diameter. The resulting material, consisting of particles smaller than 2 mm, was used for laboratory analysis. The core method, as outlined by Blake and Hartge (1986), was employed to determine the bulk density. The hydrometer method, described by Gee and Or (2002), was utilized to analyse the particle size distribution. Soil reaction, or pH, was determined in a water solution with a soil-to-solution ratio of 1:2.5, using a Pye Unicam model 290 MK pH meter (Agbenin, 2005). To measure organic carbon, the acid dichromate wet oxidation method by Walkley and Black, as described by Nelson and Sommers (1986), was employed. The Macro Kjedahl method (Bremmer and Mulvaney, 1982) was used to determine total nitrogen content. Available phosphorus was assessed using the Bray-1 method outlined by Bray and Kurtz (1945). Exchangeable acidity was determined using the method described by Thomas (1982). Exchangeable bases (calcium, magnesium, potassium, and sodium) and cation exchange capacity (CEC) were determined using a neutral (pH 7.0) ammonium acetate (NH4OAc) solution, as described by Anderson and Ingram (1993). Base saturation (BS) was calculated by dividing the sum of exchangeable bases (Ca, Mg, K, and Na) by the CEC. The exchangeable sodium percentage (ESP) was calculated as the proportion of CEC occupied by sodium cations.

RESULTS AND DISCUSSION

Table 1 showed that the sand fraction dominates the mineral composition of the orchard soils. This can be attributed to the parent material, which is rich in quartz minerals, an essential component of granite (Shobayo *et al*., 2019). In addition, biological activities, clay migration through eluviation and illuviation, and surface erosion by runoff, either individually or in combination, contribute to the sorting of soil materials, thus influencing the sand content (Aliyu, 2023). The distribution of silt content in the soils appears to be irregular (Table 1). Previous studies by Shobayo *et al*. (2019) and Jimoh *et al*. (2022) in the Savanna region of Northern Nigeria have suggested that the irregularity in silt content can be influenced by Harmattan dust. Clay content tends to increase irregularly within soil depth, often exhibiting higher values in the subsurface horizons. This increase can be attributed to illuviation and pedoturbation processes (Aliyu, 2023).The bulk density values presented in Table 1 fall within the critical range of 1.4 to 1.65 Mg m^{-3} for clayey soil, as indicated by Donahue *et al*. (1990). These values suggest that the soils are suitable for plant growth and facilitate root penetration.

Table 1: Physical properties of the soils of IAR Horticultural orchard

Horizon	Depth cm	Sand g kg^{-1}	Silt	Clay	Textural class	Bulk Density (g/cm^3)
Pedon 1						
Ap	0-16	450.00	400.00	150.00	Loam	1.61
BA	16-36	450.00	340.00	210.00	Loam	1.58
Bt	36-97	250.00	280.00	470.00	Clay	1.57
Btc	97-166	230.00	320.00	450.00	Clay	1.54
Pedon 2						
Ap	0-23	430.00	240.00	330.00	Clay loam	1.67
B	23-70	450.00	340.00	210.00	Loam	1.55
Bt	70-137	330.00	280.00	390.00	Clay loam	1.40

The chemical characteristics of the soils in the IAR orchard are presented in Table 2. The soil reaction was found to be moderate to slightly acid. Aliyu (2023) suggests that this acidity may be attributed to both the chemical nature of the underlying parent materials and the limited leaching of soluble salts in the soil. The mean pH value (6.04) is slightly higher than values reported by other researchers (Shobayo, 2010; Aliyu *et al*., 2016) in the northern guinea savanna. This difference could be attributed to reduce leaching caused by the presence of tree canopies and branches, which diminish the impact of raindrops. The organic carbon content in the soils ranged from 6.80 to 9.20 g kg^{-1}, indicating a low rating according to Soil Survey Staff (1993) criteria. The decrease in organic carbon content with depth can be attributed to the influence of biomass on the surface horizons. Similarly, the total nitrogen content was rated as low, suggesting rapid organic matter mineralization in the savanna soils. The available phosphorus content was also low, with significant quantities found only in the surface soil. The values remained below the thresholds for low, moderate, and high levels (6, 6-12, and >12, respectively). The exchangeable bases in the soils were generally low to medium, with calcium and magnesium being the predominant basic cations. Similar observations have been made for tropical soils in general (Aliyu, 2023).

Table 2: Chemical properties of the soils of IAR Horticultural orchard

Horizon	Depth	pH		OC	TN	Av.p	Ca	Mg	K	Na	TEA	EA	CEC	ESP	BS
		H_2O	$CaCl_2$	g kg^{-1}		mgkg^{-1}	cmolkg^{-1}								%
Pedon 1															
Ap	0-16	6.10	5.80	6.80	0.85	5.43	0.80	0.20	0.23	0.09	1.32	0.04	5.70	1.58	23.16
BA	16-36	6.10	5.70	2.90	0.36	2.98	0.80	0.22	0.12	0.13	1.27	0.05	6.60	1.97	19.24
Bt	36-97	6.40	5.90	1.20	0.15	3.50	1.80	0.49	0.17	0.08	2.54	0.04	9.60	0.83	26.46
Btc	97-166	6.00	5.80	0.80	0.10	3.50	1.60	0.43	0.27	0.23	2.53	0.05	9.40	2.45	26.91
Pedon 2															
Ap	0-23	6.20	5.80	9.20	1.15	5.95	1.40	0.38	0.13	0.05	1.96	0.04	8.40	0.60	23.33
B	23-70	5.80	5.60	2.70	0.34	4.90	1.80	0.47	0.14	0.05	2.46	0.10	6.50	0.77	37.85
Bt	70-137	5.70	4.60	1.00	0.13	4.03	2.20	0.59	0.12	0.12	3.03	0.10	8.30	1.45	36.51

The exchangeable acidity (EA) was rated as low, indicating the absence of aluminium toxicity in the orchard soils. The highest exchangeable acidity values were found in the surface horizons and decreased with increasing soil depth. The moderate cation exchange capacity (CEC) of the soils can be attributed to the mixed mineralogy of the clay minerals (Shobayo *et al*., 2019). While organic matter typically influences CEC, the low organic content observed in terms of carbon, nitrogen, and phosphorus suggests that the CEC values may not be solely associated with organic matter contribution. Base saturation in the orchard soils was rated as low, falling within the range of 19.24 to 37.85%. According to FAO (1999), soils with base saturation above 50% are considered fertile, while those below 50% are classified as infertile. Based on this classification, the soils in the orchard are generally infertile. The exchangeable sodium percentage (ESP) values were below the critical limit of 15% for sodicity, according to Brady and Weil (2002), indicating that sodicity is not a problem in the orchard soils. Furthermore, the ESP values were less than 20%, falling under the excellent category, which is indicative of a fertile soil status.

CONCLUSION

In conclusion, the analysis of the orchard soils in IAR reveals several important findings. The dominant mineral composition is sand, which can be attributed to the presence of quartz minerals in the parent material. The bulk density values indicate that the soils are suitable for plant growth and root penetration. The moderately to slightly acidic soil reaction is influenced by the chemical nature of the parent materials and limited leaching of soluble salts. The presence of tree canopies and branches may contribute to reduced leaching, resulting in slightly higher pH values compared to other studies in the region. The organic carbon content is rated as low, decreasing with depth due to the influence of biomass on the surface horizons. Similarly, the total nitrogen and available phosphorus contents are low, suggesting rapid organic matter mineralization and limited phosphorus availability. The exchangeable bases in the soils are generally low to medium, with calcium and magnesium being the predominant cations. The absence of aluminum toxicity is indicated by the low exchangeable acidity values. The moderate cation exchange capacity is influenced by the mixed mineralogy of the clay minerals. The soils in the orchard are classified as infertile based on their low base saturation values. However, sodicity is not a problem, as the exchangeable sodium percentage remains below critical limits.

Overall, the findings suggest that the orchard soils require amendments to improve fertility and nutrient availability for optimal plant growth. This could include organic matter additions, phosphorus fertilization, and the application of appropriate soil amendments to enhance cation exchange capacity and base saturation. Further research and management strategies can be implemented to address the specific needs of the orchard soils, promoting healthy and productive plant growth.

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FERTILITY STATUS OF SOILS UNDER THREE LAND USE TYPES IN OHAJI-EGBEMA, SOUTHEASTERN NIGERIA

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ABSTRACT
This study was to investigate the soil fertility status in Ohaji-Egbema of Imo state, southeast Nigeria. Five (5) typical soil samples were collected at 0–30 cm depth from three distinct land uses: oil palm plantations, cassava farms, and fallow land. Bulk density was determined using core samplers. After air drying, the samples were sieved through 2 mm mesh, and routine laboratory analyses were performed. ANOVA was used to analyze the data, and the means were divided using the least significant difference at the probability threshold of (p = 0.05). The mean sand fraction in cassava farms ranged from 886 g kg^{-1} to 952 g kg^{-1}, and the mean silt and clay contents ranged from 32 g kg^{-1} (fallow and oil palm) to 52 g kg^{-1} (cassava), respectively. The bulk density of the soils ranged from 1.04 to 1.12 g/cm^{-3}; however, there was no significant difference in the mean bulk density of the soils (p=0.05). Chemical analysis of the soil of the study area revealed a mean pH range of 5.84 in fallow land to 6.49 in cassava soil. The pH levels of the various land use types did not significantly differ, according to the results (p = 0.05). The organic carbon and matter range was 0.97-1.19 and 1.67-2.05 g/kg, respectively. The nutrient index and fertility rating results suggested that the study area had generally low fertility rates.
Keywords: *Critical limits, nutrient index, soil suitability, land use types, soil fertility*

INTRODUCTION
Agricultural use of floodplain soils has increased significantly recently in most developing nations, particularly in Africa, including Nigeria (Akpan *et al.*, 2017). Farmers go to flooded areas for their activities because they are known to be very fertile for farming. Water and nutrients are available for sustainable crop growth in these areas (Eshett, 1990). In Nigeria, about 4.62 million hectares of land space are characterized for wetland and rice cultivation, and only 11.25% of these lands are being used worldwide (Olaleye *et al.*, 2001). Floodplain soil is essential to agricultural production as it is known to have a considerable reserve of available nutrients for the utilization of crops, especially rice (Akpan-Idiok and Ogbaji, 2013).
Many researchers have employed nutrient ratios in plant tissue to diagnose mineral nutrient deficiencies in crops (Sumner, 1978). Ca/Mg, K/Mg, K/Ca, N/P, and (Ca+Mg)/K are some regularly seen ratios in the literature and are usually a reflection of some recognized nutritional antagonism. (Olaleye *et al.*, 2009; Obasi *et al.*, 2016). When the cations calcium (Ca), magnesium (Mg), potassium (K), and hydrogen (H) occupied the cation exchange sites in the exact percentages of 65%, 10%, 5%, and 20%, respectively, soil productivity was discovered to be ideal for certain crops. They calculated cation equivalent ratios of Ca:Mg 6.5:1, Ca:K 13:1, and Mg:K 2:1 using these saturation percentages. Graham (1959) later revised the saturation percentages to be 65-85% Ca, 6-12% Mg, and 2-5% K. Graham's percentage ranges are the current figures for the Basic Cation Saturation Ratio hypothesis. Loide (2002) recommended 10-20:1 (Ca/Mg) and 3:1 (K/Mg) ratios for optimum yield and productivity of crops. Many basic cation saturation ratio interpretations, however, continue to be done using the precise cation ratios of 6.5:1, 13:1, and 2:1, rather than interpreting a range of ratios that could be created from Graham's percentages, Ca:Mg 5.4:1-14:1, Ca:K 13:1 - 42.5, and Mg:K 1.2:1 - 6:1.
Many studies on soil fertility focus on managing nutrients to improve crop production. The fertility status and properties of soils of the floodplain have not been adequately investigated and evaluated in most parts of the country, especially in South-Eastern Nigeria, where some works have been done on the fertility status of the floodplain (Nkwopara *et al.*, 2019). Also, Onwudike *et al.* (2016) studied the fertility status of selected soils in

Mbaise, Imo State, Southeastern Nigeria, using the nutrient index method. However, there needs to be more information on the fertility status of soils of the floodplain, especially in the Ohaji/Egbema area Owerri of Imo State. Therefore, this study aimed to investigate the nutrient status of floodplain soils under three land use types in southeastern Nigeria's Ohaji/Egbema location.

MATERIALS AND METHODS

The study was conducted at Ohaji-Egbema in Owerri, Imo State, Southeast Nigeria. Ohaji lies between Latitude 5^{o} 19^{1} and 5^{o} 32^{1} N and between Longitude 6^{o} 45^{1} and 6^{o} 59^{1} E. Orajaka (1975) reported that Ohaji-Egbema soils are formed from a parent material primarily known to be Coastal plain sand, otherwise known as Benin formation and had instead been classified as Alfisols or Ultisols (Obasi *et al.*, 2015). Ohaji Egbema, located in the humid tropical rainforest region, has a mean monthly temperature of about 27^{o}C and a mean annual rainfall of about 1700-2400mm. The area has a bimodal rainfall distribution with peaks in July and September and a short break in August, known as the August break (NIMET, 2020). The dominant socio-economic activity in Ohaji-Egbema is agriculture dominated with food crops such as yam *(Dioscorea* spp), cassava *(Manihot* spp*)*, Fluted pumpkin *(Tefeira ocedentalis)*, and maize *(Zea maiz)*, all at a substantial level**.**

Field study

The study was conducted on a floodplain of three different agricultural land use types.; 2-year continuously cultivated cassava farmland, fallow land (secondary forest), and oil plantations were randomly selected for the study. Soil auger was used to collect soil samples from each land use type at 0-30cm depth. Five (5) soil samples were collected from each land use type at an equal distance of 5 meters apart. A total of 15 soil surface samples were collected. A core sampler collected soil samples for soil bulk density determination. Soils collected were bagged, transported to the laboratory, air-dried at room temperature, crushed, and sieved using a 2 mm mesh sieve for analysis.

Laboratory Analyses

Fertility evaluation

The fertility status of the soils was determined using the elemental ratios; Ca:Mg ratio was determined by dividing the value of exchangeable Calcium by the value of exchangeable Magnesium. C: N ratio was determined by dividing the organic carbon value by the total Nitrogen value. K: Mg ratio was determined by dividing the exchangeable potassium value by the exchangeable magnesium value. **Sodium Adsorption ratio (SAR):** this was determined using the equation as follows: SAR = $\frac{(Na^{+})}{(\frac{(Ca^{2+})+(mg^{2+})}{2})^{\frac{1}{2}}}$ While Na^{+}, Ca^{2+}, and Mg^{2+} are concentrations of sodium, calcium and magnesium ions in millimoles (mmol) of charge per liter.

Exchangeable Sodium Percentage (ESP): this was obtained using the equation below;

ESP = $\frac{exchangeNa^{+}}{ECEC}$ X $\frac{100}{1}$ Where ECEC = Effective cation exchange capacity.

Aluminum saturation: this was calculated as follows; Al sat = $\frac{Al^{3+}}{ECEC}$ X $\frac{100}{1}$

Statistical Analysis

Data collected were subjected to Analysis of Variance (ANOVA), and significant means were separated using Least Significant Difference (LSD) at a 0.05 probability level (Wahua 1999). The relationship among soil properties was determined using correlation analysis and scattered diagrams.

RESULTS AND DISCUSSION

Physical Properties of the Studied Locations

The results of selected soil physical properties of the study location are shown in Table 1 Particle size distribution was dominated by the sand fractions. The mean sand content ranged from 886-952g/kg. From the results, the sand contents of the soils differed significantly (p=0.05), with fallow land having the highest mean. Similarly, significantly different (p=0.05) was recorded in the silt and clay contents of the varying land use types, which ranged from 16-22g/kg and 32-52g/kg in the land use types of fallow land, cassava farm and oil palm plantation respectively. But fallow and oil palm have the same clay. However, the soils of the cassava farm had significantly the highest silt and clay contents. The geology of the area could explain the high percentage of sand seen in all land use schemes. The area's geology includes coasted plain sands with sandy soils spread across a large area of land (Akamigbo and Ukaegbu, 2003). Bulk density ranged from 0.91-1.25 g/cm^3 for fallow land,1.08 –1.19 g/cm^3 cassava farm, and 0.96 – 1.16 g/cm^3 in oil palm plantation. According to the mean values, Cassava farms had the most significant bulk density among the land use patterns evaluated. The bulk density result is consistent with Osuji *et al.* (2011) observations on soils in South Eastern Nigeria. Total porosity (TP) ranged from 52-65% in fallow land, 55-59% in cassava farms, and 56-63% in oil palm plantations. The mean values of the TP indicated that the oil palm plantation had the highest (60.20%) while the cassava farm had the least (57.60%). From the soil's Total porosity results, the soils are dominated by a high sand fraction with high total porosity and moisture content. These soils, therefore, require proper management practices that could improve the soil's physical qualities.

Moisture Content (MC) ranged from 94.25 – 98.25% in fallow land, 91.82– 95.49% in cassava farm, 95.38 – 96.54% in cassava cultivated land in 11.33-13.02% in oil palm plantation. The mean Moisture Content values showed that fallow land had the most significant (96.79%) and cassava farm had the lowest (94.25%). The high MC value of the Fallow land could be attributed to the poorly drained nature of the soil and the area's flooded status, which can be remedied with a sufficient drainage system. Depending on the textural class, land use system, soil structure, and vegetation, moisture content differs amongst land use types. The findings are consistent with Brady and Weil (2007) claim that soil physical parameters and quality influence soil moisture content. The silt clay ratio (SCR) ranged in land use categories from 0.31 to 1.25, 0.09 to 2.5, and 0.31 to 1.25 in fallow land, cassava farmed land, and oil palm plantation order. The SCR values of the investigated land use types are consistent with the findings of Hassan *et al.* (2016), who reported that SCR values less than one (1) suggested that the soils are significantly eroded and possess a ferrallitic character from a pedological perspective.

Table 1: The means of the soil physical properties of the study location

Land used	Sand gkg-1	Silt gkg-1	Clay gkg-1	TC	BD gcm-3	TP %	MC %	SCR
Fallow	952	16.0	32.0	S	1.09	58.40	96.79	0.50
Cassava	886	42.0	52.0	S	1.12	57.60	94.25	1.12
Oil palm	946	22.0	32.0	S	1.04	60.20	96.29	0.69
LSD(0.05)	2.83	2.64	3.03	S	0.18	6.68	0.820	1.57

S = sandy, TC – Textural Class, BD = Bulk density, TP= total porosity, MC = Moisture Content, LSD = Least Significant Difference

Soil chemical properties under different land use types

The chemical characteristics of the soil (Table 2) revealed that the analyzed soil of the land use types was generally acidic. The mean pH value of the three land use types ranged from moderately acidic (5.84) in fallow land and oil palm plantation to slightly acidic (6.49) in cassava farms (FAO 2004). Acidic situations in diverse land use types could be linked to heavy leaching caused by excessive tropical rainfall (IITA, 1995; Ojanuga and Lekwa, 2005). The average organic carbon content of the examined land use types was 0.97%, 1.19%, and 1.01% for fallow land, cassava farmland, and oil palm plantation, respectively. When compared to FDALR values (<4%), the organic carbon concentration of the examined land use types was low (1985). The mean organic matter content of the examined land use systems was (1.67%, 2.05%, and 1.74%) for fallow land, cassava farmland, and oil palm plantation, respectively. Compared to FAO rates (2-4%), the O.M content of the analyzed land use systems was low (2004). The findings show that the organic carbon levels of the four land use categories evaluated coincided with the findings of Ufot *et al.* (2016) of soils under vegetative cover in southeastern Nigeria.

The change in TN could be due to a significant buildup of organic material on the surface horizon, the rate of decomposition, and the rate of illuviation and illuviation. Several researchers' findings in soils with comparable agroecology (Hassan *et al.*, 2016; Chude *et al.*, 2011; Ufot *et al.*, 2016) corroborate the findings. Total nitrogen mean ranged (0.12%, 0.13%, and 0.12%) for fallow land, cassava farmland, and oil palm plantation, respectively, in the analyzed land use systems. The mean levels of T.N in all land use types were less than the threshold value of (0.15%) for Nigerian soils (FDALR, 1985, Chude *et al.*, 2011). Low N concentrations in soils could be attributed to quick mineralization of soil organic matter and severe leaching caused by heavy tropical rainfall (Howeler, 2002; Ojanuga and Lekwa, 2005). On the fallow ground, cassava agricultural land, and oil palm plantation, the available phosphorus had mean values of 1.92 mg/kg, 2.83 mg/kg, and 3.99 mg/kg, respectively. The FDALR grade (<6, <5) indicated that the available phosphorus in all of the land use systems investigated was low (1985). The low accessible phosphorus value could be owing to a high sorption reaction. Low accessible phosphorus levels have been ascribed to soil weathering, clay type, severe leaching, rainfall, and absorption reaction by soil elements (Hillocks, 2002). The effects of fixation and erosion might also contribute to a decrease in accessible P. The available phosphorus increased with increasing soil organic matter and cation exchangeable capacity under diverse land use regimes.

The exchangeable bases values revealed that Sodium (Na), Potassium (K), and Magnesium (Mg) levels in the fallow land were low when compared to Calcium (Ca) levels. On cassava farmland, potassium (K) and magnesium (Mg) have equivalent means. Ca, Mg, K, and Na mean values are (2.80 cmol/kg, 1.08 cmol/kg, 0.80 cmol/kg, and 0.94 cmol/kg) for oil palm plantation land, (3.46 cmol/kg, 1.18 cmol/kg, 1.18 cmol/kg, and 0.79 cmol/kg) for cassava farmland, and (3.28 cmol/kg, 0.98 cmol/kg. Exchangeable bases readings revealed that Sodium (Na), Potassium (K), and Magnesium (Mg) levels were low in comparison to Calcium (Ca) levels in fallow land. Potassium (K) and magnesium (Mg) have equal mean values on cassava farmland. Ca, Mg, K, and Na mean values are (2.80 cmol/kg, 1.08 cmol/kg, 0.80 cmol/kg, and 0.94 cmol/kg) for oil palm plantation land, (3.46 cmol/kg, 1.18 cmol/kg, 1.18 cmol/kg, and 0.79 cmol/kg) for cassava farmland, and (3.28 cmol/kg, 0.98 cmol/kg.

Low organic matter and high weathering could explain the low amount of ECEC in the terrain types (Akamigbo and Asadu, 1983). In all land use types, the ECEC increased unevenly with soil depth. The percentage base saturation (%BS) for fallow land, cassava farmland, and oil palm plantation land use types was (90.54-94.84%), (85.02-91.72%), and (84.10-93.80%), respectively, according to the results of the soil chemical characteristics under diverse land use types. According to FAO assessments, the percentage base saturation mean suggested that all land use types were high (2004). The percentage BS results show that primary cation dominates cation exchange capacity in all land use types. The fallow land use type had the highest mean value (92.52%), and the cassava farmland use system had the lowest (89.90%) among the land use kinds. The findings on percentage base saturation of the analyzed land use systems contradict Igbokwe's (1990) work on soil fertility and land use patterns in Nigeria's eastern states. Nevertheless, parent material, weathering rate, and global climate change may have contributed to the variation shown by the findings (Onweremadu *et al*., 2011, Wang et al., 2001).

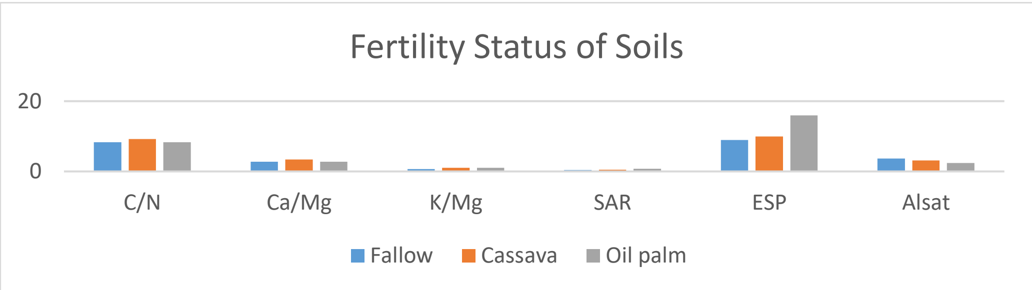
Table 2: Means of Soil chemical properties of the study location

Land used	pH	Org Carbon %	Org. Matter %	Total N %	Avail P Mg/kg	Ca	Mg	K	Na Cmolkg^{-1}	H	Al	TEB	TEA	ECEC	BS %
Fallow	5.84	0.97	1.67	0.12	1.92	3.28	0.94	0.64	0.55	0.38	0.27	5.41	0.44	5.85	92.52
Cassava	6.49	1.19	2.05	0.13	2.83	3.46	1.18	1.18	0.79	0.60	0.22	6.60	0.78	7.38	89.00
Oil palm	6.02	1.01	1.74	0.12	3.99	2.80	1.08	0.80	0.94	0.47	0.16	5.62	0.56	6.18	90.16
LSD(0.05)	0.74	0.27	0.47	0.02	2.67	1.21	0.68	0.77	0.59	0.15	0.121	2.61	0.31	2.87	3.21

ECEC = effective cation exchange capacity, BS = Base saturation, TEB = Total Exchangeable Bases, TEA = Total Exchangeable acidity

Some fertility indicators of soils in the study area

The results in Fig. 1, which shows some fertility ratios, indicated that all the elemental ratios are not significant. In all land use classifications, the median of C:N ratios indicated fertile, ranging from 8.29 to 9.21. When the C: N ratio is between 1 and 15, fast mineralization and N release occurs, making N accessible for plant uptake. The lower the C: N ratio, the faster nitrogen is released into the soil for immediate crop utilization. (Watson *et al.*, 2002). A C: N ratio > 35 results in microbial immobilization. Ca: Mg showed that fallow land and palm plantation were unfertile with means of 2.80 and 2.78, respectively. According to Johnstone (2011), the Ca: Mg ratio in fertile soils is typically in the range of 3:1-7:1. Landon (1991) also said that a Ca: Mg ratio less than 3:1 indicates infertile soils. Except for barren land, which had a mean of 0.70, the K:Mg values suggested fertile land. It has been reported that ideal K: Mg ratio in fertile soils is in the range of 0.2-.0.35 and the K: Mg ratio greater than 2:1 may inhibit the uptake of Mg (Udo *et al*., 2009). Sodium adsorption ratio (SAR) indicated fertile land use types with means of 0.37, 0.51 and 0.73 in the fallow land, Cassava farm land and oil palm plantation respectively. When the sodium adsorption ratio (SAR) is >13, the soil contains sufficient sodium to interfere with the growth of most crop plants, meaning its infertile (Brady and Weil, 2010). The ESP of the fallow land and Cassava farm is fertile while oil palm plantation is infertile with the mean of 15.96. If exchangeable sodium percentage (ESP) is >15 it is associated with severely deteriorated soil physical properties and pH values of 8.5 and above, making the soil infertile.



ALSAT = Aluminum Saturation, ESP = Exchangeable Sodium Percentage, SAR = Sodium Adsorption Ratio.
Fig. 1: Mean of Some fertility indicators of soils in the study area

CONCLUSION

The particle size distribution demonstrated that sand dominated other soil fractions across the three land use categories tested. When compared to other land use types, Cassava farm land had a high bulk density. Overall porosity was high, with the greatest mean seen in oil palm plantations. The moisture content was high, with fallow land having the most moisture. All lansd use types had low levels of organic carbon, organic matter, accessible phosphorus, and total nitrogen. The exchangeable cation ranges from low to high, but the effective cation exchange capacity was low. The percentage of base saturation was very high. C/N elemental ratios indicated fertile in all land use types, Ca/Mg indicated unfertile in fallow land and palm plantation, K/Mg indicated infertile in fallow land, and SAR indicated fertile in all land use types. Yet, as compared to the critical level (0.6 mg/kg), the zinc content in the research area was quite low. This shortage is caused by the organic carbon level of study area. The copper concentration of the study area differed significantly. Despite the fact that the copper concentration was below the threshold limit of 0.2 mg/kg. This shortage can be linked to the high sand content of the study area, which restricts the available copper content in the soils. Generally, iron, copper, and zinc were all found to be below the critical limits in the soils of Ohaji-Egbema for the three land use categories, which can be attributed to the leaching effect of the floodplain soil.

This study investigated the soil fertility status of Ohaji-Egbema in Imo state, southeastern Nigeria, across three distinct land use types: oil palm plantations, cassava farms, and fallow land. The analysis revealed variations in soil texture, with cassava farms exhibiting higher sand content and clay-silt composition than other land use types. Bulk density showed minor fluctuations across the sites. While pH levels differed slightly among land use types, they remained within an acceptable range. Organic carbon and matter content varied within relatively narrow limits. However, overall nutrient indices and fertility ratings indicated a prevailing condition of low fertility across the study area. These findings underscore the importance of implementing targeted soil management practices to enhance fertility and sustain productivity across diverse land use contexts in this region. Further research could explore specific soil improvement strategies tailored to each land use type for more effective and sustainable agricultural practices.

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INFLUENCE OF COW DUNG AND PIG MANURE ON SELECTED SOIL PROPERTIES AND YIELD OF OKRA (*ABELMUSCUS ESCULENTUS*)

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ABSTRACT
An experiment was carried out at the Research Farm of Oyo State College of Agriculture and Technology, Igboora, Oyo State. The research objective was to assess the effect of Cow dung (CD), and Pig manure (PGM) on soil properties and yield of Okra. The experimental design was a Randomized Complete Block Design (RCBD), replicated five times. The treatments used in the study were; Control (CO), 5 t/ha (CD and PGM) and 10 t/ha (CD and PGM). Data were collected on yield components and subjected to Analysis of Variance (ANOVA). Application of Cow-dung and pig manure significantly influenced ($p<0.05$). Number of harvested pods, fresh and weight of dry pods were significantly ($p<0.05$) higher compared to control. The result indicated that application of 5 t/ha (CD and PGM) significantly ($p<0.05$) improved okra performance. Conversely, CD and PGM at $10tha^{-1}$ did not result in corresponding increase in the growth and yield of Okra. Also, the results showed that the addition of CD and PGM significantly ($p<0.05$) improved some soil chemical properties (pH, total N, available P, Organic matter and cation exchange capacity). Thus, application of CD and PGM at 5 tha^{-1} is recommended for use to improve soil fertility status for sustainable Okra production in the study area.
Keywords: *Pig manure: Cow dung; Okra,*

INTRODUCTION
Okra (*Abelmoschus esculentus* [L], is a valued vegetable in different parts of Nigeria, mainly for its delicious fruits. It can be consumed alone or in combination with other foods. Nutritionally the dry seed has been considered the richest part of the crop (Adelakun, *et al.*, 2009). The crop occupies about 1.5 million hectares of the arable land in Nigeria (IFA, 1992). Its world production as fresh fruit vegetable has been estimated at 1.7 million t/year (Schippers, 2000). However, Okra cultivation is affected by low yield, partly because of low soil fertility.
Recently, farm yard manure recycling is one of the main options adopted in agriculture because of its richness in plant nutrients, especially N and P (Bello, *et al.*, 2017). Similarly, the application of organic manures had been found to have higher comparative economic advantage over the use of inorganic fertilizer. Manure is relatively cheap when compared with mineral fertilizers. Thus, it is a better option of improving soil fertility status with minimum effect on the soil properties,
Bello *et al.*, (2019) observed that in households where crop and livestock production are integrated, farmyard manure and their compost are valuable sources of amendments for improving soil fertility and sustaining crop production, especially in the sandy loam soils such as found in some locations of Oyo State, South-west Nigeria (Bello and Adejuyigbe, 2012).
In view of the constraints associated with fertilizer usage in tropical agriculture (unaffordability due to high prices), more small farmers in Africa may consider the adoption of organic manure (cow-dung and pig manure), on soil properties and Okra yield.

MATERIALS AND METHODS
The study was conducted at the Teaching and Research Farm, Oyo State College of Agriculture and Technology, Igboora, located in the Derived Savanna Zone, Nigeria. The region has two prominent rainy periods ranging from 1000 to 1600 mm of annual rainfall and temperature between 22^{o}C to 38^{o}C. Okra seeds (var. Lady's finger) were obtained from National Horticulture Research Institute, (NIHORT), Ibadan, Oyo state, Nigeria.
Experimental site was manually ploughed and harrowed, and demarcated into plots of 1.5 x 1 m dimension. The soils of the experimental site were randomly sampled at depths of 0-30 cm before and after planting using auger.

The soil samples were bulked, air-dried and sieved through 2 mm mesh and analyzed for selected physical and chemical properties (pH taken in a 1:25 solution of 10 g air-dried soil + 25ml distilled water or 1MKCL solution). Texture was determined by pipette method. Samples were fractionated using Vanluwe *et al.*, (1998) method. The Olsen-P method was used to determine available phosphorus concentrations in the soils. Percentage total nitrogen was measured by the Kjeldahl digestion method, while the Amato method was used to measure percentage total soil carbon (Amato, 1983).

Treatments used were: control (Co), Piggery manure (PGM), applied at 5 t/ha and 10 t/ha (CD and PGM) respectively,. The experimental design was a Randomized Complete Block Design (RCBD) replicated three times. Each plot measured 3 m x 3 m. The manures were first subjected to routine laboratory analysis to determine their nutrient status and applied a week before planting to hasten decomposition and enhance nutrient use efficiency by the testcrop. The manures were worked into the soil with the aid of small African hand-held hoes, while the Okra seeds were planted a week after by drilling. Okra seeds were planted at 0.25 m within rows and 0. 5 m between rows and the seedlings were thinned to one plant per hill two weeks after planting (WAP). Weeding was carried out regularly by hand pulling up to 6 WAP.

RESULT AND DISCUSSION

The result of the soil analysis carried out before planting is presented in table 1. The results showed that the soil was sandy loam in texture, with high proportions of sand (75.4 %), likely to cause basic cations (Ca, K, Na and Mg), to easily leach. The soil was slightly acidic in pH (6.6), low in organic carbon, total nitrogen and available P. The low organic carbon and organic matter content of the soil could be as a result of the sandy loam texture of the study soils. Also, the low nutrient content of the soil could be attributed to continuous cropping and increased land use (Mafongaya *et al.*, 2003). Thus, the low soil OC, N, P, K, Mg content and its acidic status justify the need for the application of goat and Cow-dung manure (Table 1).

Table 1: Pre-Soil properties of the experimental site and chemical properties of the manures

Parameters	Value	Pig-manure	Cow-dung manure
Physical characteristics			
Sand %	75.4	----------	---------
Silt %	13.6	-----------	----------
Clay %	11	------------	----------
Textural class	Sandy loam	------------	----------
pH (H20)	6.6	**8.06**	**8.74**
Org C	1.54	-------	------
Total N%	0.12	**1.53**	**1.65**
C/N	12.83		
P (mg/kg)	18.6	**320**	**389.85**
Ca(cmol/kg)	0.42	**8.2**	**9.1**
Mg ,,	1.4	**37.21**	**36.52**
K ,,	0.57	**5.6**	**7.6**
Na ,,	0.53	**2.68**	**7.08**
Acidity ,,	0.4	--------	-------
Mn ,,	0.1	----------	--------
ECEC	3.68	----------	--------
Temperature (0C)	-----	**27.2**	**27.4**

Table 2: Effect of Cow-dung and Pig manure on number of harvested pods, fresh and dry weight of pods of Okra

Treatments	Number of Pods	Fresh weight of Pods	Dry weight of Pods
Control	32.66e	0.56e	0.18d
Pgm5t/ha	75.56dc	0.86cd	0.22c
Pgm 10t/ha	110.60b	1.25b	0.27b
CD 5t/ha	86.20c	0.97c	0.24c
CD 10t/ha	126.16a	1.36a	0.29a

Means followed by the same letter in the columns are not significantly different at 5% level of probability by DMRT.

Pgm – Pig manure, CD – Cow-dung manure.

Table 2, indicated that the application of cow dung and poultry manure) significantly ($p<0.05$), increased number of pods, fresh weight of pods and the dry weight of pods respectively. The highest number of pods, fresh weight of pod and dry weight of pods was obtained at 5 t/ha (CD and PGM) followed by 10 t/ha (CD and PGM). The use of 5 t/ha (CD and PGM), produced higher yield than 10 t/ha (CD and PGM). This increase in Okra yield associated with increased in the rate of CD and PGM is consistent with the observation of Bello *et al.*, (2018).

Table 3: Soil properties of the experimental site after harvesting

Parameter	Control	PGM 5t/ha	PGM 10t/ha	CD 5t/ha	CD 10t/ha
Physical characteristics					
Sand %	75.4	74.70	70.40	75.00	71.00
Silt%	13.6	10.0	11	10.00	10.00
Clay %	11	15.30	18.60	15.00	19.00
Textural class	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam
pH(H_20)	6.6	6.60	7.25	6.55	7.30
Org. C%	1.54	2.14	2.62	1.96	2.96
Total N%	0.12	0.21	0.43	0.36	0.49
C/N ratio	12.83	10.19	6.09	5.44	6.04
P (mgkg-1)	18.6	27.48	22.53	27.10	19.39
Ca (cmolkg-1)	0.42	5.26	7.66	2.06	4.46
Mg ,,	1.4	4.93	6.13	1.33	3.73
K ,,	0.57	1.05	0.71	0.71	1.01
Na ,,	0.53	0.54	0.88	0.49	0.93

Addition of cow-dung and poultry manures enhanced the improvement in soil chemical properties, (pH, total N, available P, Organic matter, exchangeable cations and cation exchange capacity was improved), (Table 3). Application of cow dung and pig manure could be used for soil management as it improves soil nutrient status and enhanced the sustainable production of crops. The observed result corroborates the findings of Sanni and Adenubi, (2015) who reported that application of pig and goat manure is recommended for sustainable Okra production. The results obtained showed that okra responded well to the application 5 t/ha (CD and PGM) than the use of 10 t/ha (CD and PGM), (improved soil organic matter and nutrient availability), hence enhancedyield. The application of 5 t/ha (CD and PGM) is therefore, recommended for optimum production of okra and restoration of soil fertility.

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EFFECTS OF FERTILIZER APPLICATION, SPACING AND WEED CONTROL METHOD ON PERFORMANCE OF SWEET POTATO (*IPOMOEA BATATA* [L.]) LAM

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ABSTRACTS
Field experiments was conducted at Faculty of Agriculture research farm Lafia in 2020 and 2021 rainy season. These comprised of two plant spacing (35 x 75 and 40 x 75 cm), fertilizer applications (NPK at the rate of 0, 30 and 60 kg ha^{-1}), and weed control methods, using herbicides (pre-S-Methalachlor®, post-Fusillade®, hoe weeding [at 3 and 6 weeks after planting (WAP)] and weed check (control). The experiments was laid out in a split-split plot design replicated three times. The field experiment results of 2020 and 2021 indicated that fertilizer application of NPK 15:15:15 applied at the rate of 60 kg ha^{-1} recorded the highest growth parameters and yield followed by 30 kgha^{-1} fertilizer application supplemented with the application of pre-emergence herbicide of S-Metolachlor followed by hoe weeding at 6 (WAP) with plant spacing of 40 x 75 cm which gave the highest yield 6.78 tons ha^{-1} and 7.70 tons ha^{-1} and the 30 kgha^{-1} fertilizer application recorded 6.08 tons ha^{-1} and 6.30 tons ha^{-1}, during 2020 and 2021 season respectively. The results showed that both growth and yield performance of sweet potato were better with weed control method using pre-S-Metolachlor within 4 -10 days after planting (DAP) with the application of 60 kg ha^{-1} of fertilizer NPK 15:15:15 should be adopted .
Keywords: *Sweet potato, herbicides (pre-S-Metolachlor, post-Fusillade®), fertilizer rates, spacing, hoe weeding*.

INTRODUCTION
Sweet potato (*Ipomoea batatas* [L.] Lam) is one of the major staple food and perennial crops cultivated as an annual crop which serves as the most important food security promoting root crop in the world, especially in sub-Sahara Africa (Low *et al.*, 2009). The family is made up of 45 genera and 100 species. The crop is reported to have originated from Central America in about 300 BC and later introduce into Europe between 15th -20th Century. The first introduced sweet potato into Nigeria was in the late 1694 to 1698 through the early activities of Portuguese and Spanish explorer, respectively (Mbanaso, 2010). The crop was introduced by Portuguese Seafarers into Western Mediterranean Europe, Africa, India and parts of South-east Asia (Jia, 2013). Sweet potato grows at temperature between 20°C and 24°C with annual rainfall of 100 mm to 700 mm with optimal soil pH between 5 and 7 (Roullier *et al.*, 2013).

Sweet potato serves as main food crop of the tropical and subtropical areas and therefore people of rural and urban region can benefit from its nutritional advantage by enhancing their production and increasing consumption of sweet potato (Wariboko and Ogidi, 2014).

Planting on mounds and ridges are methods to peculiar to traditional peasant sweet potato production (Wubanechi, 2014). It is suggested to make the mounds 30 cm high to 40 cm wide at the base. If using a mechanical digger at harvest time it is important to match the width of the mound with the digger mouth and the higher the ridges the greater the yield of sweet potato (Bhuiyan *et al*., 2006).

Proper use of fertilizer on sweet potato production can be increased substantially. Fertilization of soil is one of the main factors to increase the yield of crops, it helps in accumulation of mineralization and humification of fertilizer when added to the soil and the plant potential can be determined by the amount of fertilizers introduced to the soil (Kolozie, 2006).

Weeds are controlled by hand weeding, hoeing and tilling between the rows by means of physical energy through implements, either manual or power operated, It has been suggested that, the use of herbicides may be a suitable alternative for managing the weeds as well as increasing the yield and ensuring the efficient use of fertilizer (Singh *et al.,* 2019). The objectives of this study was to determine sweet potato growth and yield performance to fertilizer application, plant spacing and weed control method using the herbicides pre and post emergence plus hoe weeding.

MATERIALS AND METHODS

The field experiment was conducted at the research farm Faculty of Agriculture Shabu- Lafia Campus of Nasarawa state University Keffi, situated at Latitude N 8°33' 49" Longitude E 8°33'1", with an altitude of 168.47 m above sea level (asl) (Jayeoba, 2013) during the 2020 and 2021 rainy seasons.The experimental design was a Split-split plot. The treatments consist of two plant spacings (35x75cm and 40x75cm) giving planting densities of 21,428 and 18,750 plants ha^{-1}, respectively). Laid in the main plot; two NPK (30 and 60 kgha^{-1}) and untreated control (0 kgNha^{-1}) were placed in the sub-plot and weed control methods of Pre-emergence of S-metolachlor® (Dual Gold; Syngenta) of 1160 g a.i. ha^{-1} at 4 days after planting (DAP) followed by hoe weeding at 6 WAP; Post-emergence of Fluazifop-p-butyl (Fusilade-forte®) of 450 g a.i. ha^{-1} at 2 weeks after planting (WAP) followed by hoe weeding at 6 WAP, Hoe-weeding at 3 and 6 WAP and a weedy check (control)], laid in the sub-sub plots thus, giving a 24 treatment combinations. The treatments were replicated three times to form seventy-two (72) plots. The gross plot size was 4 x 4 m (16 m^2), while the net plot size was 2 x 2 m (4 m^2). An alley of 1 m was used to separate each plot from each other and the replications (blocks). The field experiment study data collected was analyzed using ANOVA by GENSTAT software, version 13. The means were separated using Fischer's Least Significance Difference (F-LSD) at 5 % level of probability.

RESULTS

The result of Table 1 shows that the spacing with the plots of (40 x 75 cm) recorded high number of nodes (44.80) compare with the plot spacing of 35 x 75 cm (44.00) but no significantly difference during the second seasons. The number of nodes similarly were significantly higher with the application of 60 kg ha^{-1} of NPK fertilizer along sides with the application of of S-metolachlor and hoe weeding at 3 and 6 WAP compared to weedy check plots that recorded significantly lower number of nodes (36.16 and 34.80) throughout the period of observation of the both seasons.

The treatments showed that the effect of interaction on number of nodes throughout the period of observation in both years recorded not significant,

Table 1. Effect of Spacing, Fertilizer rates and Weed control methods on Number of Nodes

Treatment	**Nodes per plant (NPP)**									
	Weeks After Planting									
	2020					**2021**				
	4	**6**	**8**	**10**	**12**	**4**	**6**	**8**	**10**	**12**
Spacing (S)										
35 x 75 cm	21.10	29.14	37.5	44.24	47.19	19.57	27.62	30.10	42.75	44.73
40 x 75 cm	21.10	29.37	42.87	46.39	48.7	19.49	27.66	35.87	41.44	44.80
SE(±)	0.492	0.677	1.150	1.178	1.055	0.47	0.65	0.85	1.20	1.02
LSD	1.016	2.403	23.73	2.432	2.182	1.16	1.59	2.07	2.94	2.49
Fertilizer rates (F) (kg/ha)										
0	12.99	19.60	27.1	34.87	37.72	11.60	18.10	25.60	33.42	36.24
30	21.15	28.72	43.38	46.20	54.4	19.56	26.95	36.42	42.11	44.71
60	29.17	39.42	47.9	52.42	56.46	27.43	37.86	46.34	50.75	54.84
SE(±)	0.31	0.53	1.35	0.46	0.93	0.38	0.67	1.15	0.57	1.15
LSD	0.849	1 466	37.51	1.266	2.583	1.06	1.86	3.18	1,57	3.20
Weed control methods (W)										
S+HW 6WAP	23.53	33.15	42.8	53.41	53.41	21.87	31.72	41.36	47.94	51.55
F+HW 6WAP	19.57	27.29	35.4	44.51	44.51	17.89	25.43	33.69	39.04	43.08
HW 3 and 6 WAP	25.86	33.98	50.29	65.30	65.30	24.44	32.37	41.28	49.15	51.62
Control	15.45	22.61	28.90	36.16	36.16	13.93	21.03	27.61	32.26	34.80
SE(±)	0.72	1.14	1.57	1.30	1.30	0.72	1.04	1.27	1.80	1.42
LSD	1.51	1.40	3.31	2.73	2.73	1.46	2.11	2.57	3.66	2.88

Interaction										
S x F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x W	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
S x W	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x S x W	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS = Not Significant

The Table 2 shows that the weed dry weight was significantly influenced by weed control treatments as observed in Table 2. For both seasons (2020 and 2021), only the plots sprayed with S-metolachlor (0.84 and 0.20) followed by 6 WAP hoe weeding, Fluozifop-P-butyl (Fusilade®) (1.55 and 1.24) followed by 6 WAP hoe weeding and hoe-weeded at 3 and 6 WAP produced lower (0.91 and 0.71) compared to the season-long weedy check (5.36 and 3.83) for both seasons throughout the period of observations. The vine dry matter recorded higher weight (6.66 and 4.45) with the fertilizer application of 60 kg ha^{-1} followed by 30 kg ha^{-1} (5.04 and 3.33) compared to plots treatment with zero fertilizer application (3.30 and 2.06) throughout the period of observations for both seasons (2020 and 2021).

The highest weed densities (6.25) were observed on the spacing 40 x 75 cm at 28 DAP at first season and compared to the spacing of 30 x 75 cm (5.33) at 28DAP of weed count. There was no significant differences between the spacing of 35 x 75cm and the spacing of 40 x 75cm on weed density except at 28 DAP after the fertilizer application during the first season (2020).

The interaction effects on weight of vine dry matter at 2021 growing season shows significant.

Table 2: Effect of Spacing, Fertilizer Rates and Weed Control Methods on Weight of Vine dry Matter (VDM), Weed Dry Matter (WDM) and Weed Density @ 14 Days and 28 DAP

Treatments	**Seasons**							
	2020	2021	2020	2021	2020	2021	2020	2021
Spacing (S)	**Weight of Vine Dry matter**		**Weight of Weed Dry matter**		**Weed Count @ 14 DAP**		**Weed Count @ 28 DAP**	
35 x 75 cm	4.86	3.25	2.04	1.59	4.86	4.06	5.03	5.33
40 x 75 cm	5.14	3.31	2.30	1.70	5.81	4.25	6.25	5.47
SE(±)	0.08	0.13	0.11	0.12	0.09	0.17	0.18	0.16
LSD	0.16	0.31	0.24	0.29	0.18	0.42	1.44	0.40
Fertilizer rates (kg/ha)								
0	3.30	2.06	2.04	1.37	3.54	3.10	3.08	3.12
30	5.04	3.33	2.20	1.75	4.83	4.03	5.68	4.25
60	6.66	4.45	2.25	1.80	5.62	4.67	5.88	5.83
SE(±)	0.09	0.10	0.04	0.07	0.15	0.19	0.10	0.14
LSD	0.26	0.38	0.11	0.21	1.95	0.54	1.34	0.40
Weed control methods (W)								
S+HW 6WAP	5.89	3.63	0.84	0.20	4.97	3.22	3.94	2.83
F+HW 6WAP	4.60	3.23	1.55	1.24	5.28	3.83	5.11	4.28
HW 3 and 6 WAP	6.13	3.79	0.91	0.71	3.33	3.20	3.67	3.27
Control	3.38	2.45	5.36	3.83	6.18	6.11	8.83	6.78
SE±	0.16	0.17	0.14	0.16	0.18	0.28	0.36	0.44
LSD	0.33	0.34	0.30	0.31	1.47	0.56	1.62	0.89
Interaction								
S x F	NS	NS	NS	NS	NS	NS	NS	NS
F x W	NS	**	NS	NS	NS	NS	NS	NS
S x W	NS	NS	NS	NS	NS	NS	NS	NS
F x S x W	NS	NS	NS	NS	NS	NS	NS	NS

NS – Not Significant; -** Significant at 5 % level of probability

Interaction between Fertilizer Application Rates Weed Control Methods on Weight Vine Dry Matter during 2021 Season of Field Experiment: The interaction for fertilizer application rates and weed control methods was significant (P≤0.05) for sweet potato vine dry matter weight for 2021 cropping season. The highest weight of vine dry matter recorded was 5.30 in plots treatment of weed control with S-metolachlor and 6 WAP, with the fertilizer application NPK 15:15:15 of 60 kg ha^{-1} at both years (Table 3).

Table 3. Interaction between Fertilizer Rates and Weed Control Methods of Vine Dry Matter in Sweet Potato Production in 2020

Fertilizer (Kg)	Weed Control Vine Dry Matter 2021 S-metolachlor	Fusilade	Hoe Weeding	Control
0	2.18	2.18	2.38	1.48
30	3.42	3.20	3.75	2.75
60	5.30	4.30	5.23	2.97
LSD	0.56			

Table 4 shows that stand count had significant (P≤0.05) differences effect among the treatments. Plots treated with fertilizer applications of 60kg ha-1 recorded the highest stand count compared to no fertilizer application plots. Plot treatment of weed control (weedy check) had the lowest (78.44 and 71.94) stand count throughout the two seasons years of field research.

The number of tubers, weight of tubers per plant and the yield of sweet potato is as depicted in the results showed the influence of the application of fertilizer rates of NPK 15:15:15 of 30 and 60 kg ha^{-1} compared to plots with no fertilizer application and weed control of pre-emergence with S-metolachlor alongside with hoe weeding of 6 WAP and post emergence application with hoe weeding of 6 WAP compared to plots treatment with 0 kg application. The plots with 60 kg ha^{-1} fertilizer application with S-metolachlor and hoe 6 WAP had the highest number of tubers, weight of tubers and highest record of yield ha^{-1} (tons) at both season 2020 and 2021 (2.40 and 3.56, 0.65 and 1.05, and 6.68and 7.70). The second season had highest number of tubers, tubers weight and yield ha^{-1} (tons) compared to the first year field experiment. The plot with 0 kg ha^{-1} alongside side with weedy check had lowest number of tuber plant, tubers weight and yield ha^{-1} (tons).
There was no significant effect of interaction on tuber per plant, tubers weight and yield ha^{-1} (tons) between other factors in both year.

Table 4. Effect of Spacing, Fertilizer Rates and Weed Control Methods on Stands Count (SCPP), Number of Tuber per plant (TPP), Tuber weight per plant (TWPP), Tuber weight /plot ha^{-1} (TWPH)

Treatments	Seasons							
	2020	2021	2020	2021	2020	2021	020	2021
Spacing (S)	**Stands count/plots (SCPP) (WAP)**		**Tuber per plant (TPP) (WAP)**		**Tuber weight/plant (TWPP) (WAP)**		**Tuber yield ha^{-1} (tons)**	
35 x 75 cm	87.44	86.83	1.84	2.99	0.63	0.83	5.09	5.14
40 x75 cm	86.67	85.89	1.99	2.82	0.65	1.05	6.14	6.31
SE(±)	0.91	0.52	0.07	0.09	0.02	0.02	0.09	0.11
LSD	1.87	1.27	0.14	0.18	0.03	0.04	0.20	0.27
Fertilizer rates(kg/ha)								
0	87.29	86.21	1.65	2.11	0.42	0.52	4.08	4.18
30	86.67	86.17	2.03	3.23	0.65	1.04	6.08	6.30
60	87.21	86.71	2.06	3.38	0.85	1.26	6.78	7.70
SE(±)	1.00	0.72	0.06	0.18	0.03	0.30	0.15	0.12
LSD	2.78	1.99	0.17	0.50	0.06	0.08	0.42	0.34
Weed control methods (W)								
S+HW 6WAP	95.61	91.22	2.40	3.38	0.85	1.11	6.42	6.84
F+HW 6WAP	88.11	94.39	1.87	2.92	0.56	0.96	5.40	5.49
HW 3 and 6 WAP	93.04	94.39	2.34	3.57	0.85	1.19	6.24	7.43
Control	78.44	71.94	1.04	1.75	0.30	0.50	2.81	3.23
SE(±)	1.72	1.37	0.08	0.11	0.01	0.03	0.10	0.17
LSD	3.62	2.78	0.17	0.23	0.03	0.07	0.21	0.36
Interaction								
S x F	NS	NS	NS	NS	NS	NS	NS	NS
F x W	NS	NS	NS	NS	NS	NS	NS	NS

S x W	NS	NS	NS	NS	NS	NS	NS	NS
F x S x W	NS	NS	NS	NS	NS	NS	NS	NS

NS – Not Significant; -** Significant at 5 % level of probability

DISCUSSION

The results from the analysis of variance shows that, increase in plant spacing increased the population of large–sized tubers. The plots with spacing of 40 x 75 cm recorded higher yield (6.31). This observation is in line with the report of Arega *et al*. (2018) that the maximum weight production of tuber with wider plant spacing were due to the optimum number of nodes production with lesser competition for resources between plants compared to closer plant spacing. The application fertilizer at the rate of 60 kg ha^{-1} in combination with application of s-metalochlor and hoe weeding of 3 and 6 WAP, significantly increased numbers of nodes at 12 WAP (65.30 and 51.62). These are in agreement with the assertions of Dapaah *et al.* (2004) who emphasized that the application of nitrogen, phosphorus and potassium influenced growth and yield of sweet potato significantly. Hoe weeding was used at 3 and 6 WAP. This weed control method was effective in reducing weeds interference with sweet potato giving chance for maximum growth parameters and yield. Plots treated with pre-emergence, post-emergence and supplemented with hoe weeding and that where hoe weeding was carried out, showed high growth and yield parameters throughout the two seasons when compared to the control. This is in agreement with the assertions of Adigun and Lagoke (2003) that the use of traditional manual weeding is the most popular method of weed control among the sweet potato farmers in Nigeria.

CONCLUSION

The field experiments shows that the growth and yield of sweet potato were better with the application of 30 and 60 kg ha^{-1} of fertilizer application of NPK 15:15:15 with the wide plant spacing of 40 x 75cm followed by the weed method control of S-metolachlor for pre-emergence application carried out from 4 -10 DAP and post-emergence herbicides of Fluzifop-p-butyl (Fusilade®) applied at14 DAP followed by hoe weeding at 6 WAP. Hoe weeding at 3 and 6 WAP was one of the effective weed control methods but a tedious process

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DETAILED STUDY OF SOIL PROPERTIES VARIATION ALONG TOPOSEQUENCE IN OYO STATE COLLEGE OF AGRICULTURE AND TECHNOLOGY TEACHING AND RESEARCH FARM, IGBOORA.

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ABSTRACT
Knowledge of soil physical and chemical variability and relationship amongst soil properties is important for the evaluation of agricultural land management practice. The study was to characterize the detailed survey of the chemical soil properties variability along a toposequence of teaching and research farm, Oyo State College of Agriculture and Technology. The objective of this study is to provide invaluable information on soil variability along three topographic position, aimed at evaluating the potentials of the soil, which could assist in better management for crop production system. Different in chemical soil properties in three topographic positions (crest, lower slope and valley bottom) and 5 depths were observed on many soil properties important to crop growth. Soil profiles were described and sampled for chemical analysis. The results showed that there are various degree of variability in the chemical properties of soil in the study area. Crop residue management, construction of contour bonds and mixed cropping system are therefore suggested for sustainable exploration of land resources for crop production especially in different micro-topography area.
Keywords: *Topographic, position, growth, variability, terracing and depths*.

INTRODUCTION
Soil form a three dimensional continuum on the landscape and thus, do not exist in isolation but are organized within the landscape (Gerrard 1981; Hall, 1983). The one great constant concerning soil is their variability. Anyone who works intimately with soil soon realized that soils are anything but uniform. It is well known that soil properties vary in vertical and lateral directions and that such variation follows a systematic change (Wilding and Drees, 1983) as a function of the landscape position, the soil forming factors and/or management practices (Beckett and Webster, 1971). One can say that soils variability are the products of the five soil formation factors and as a consequence, of continuous changes over the earth's surface.
Soil variability can be as a result of the interaction among the various factors, which are topography, parent materials, climate, soil physical and chemical processes, biological activities, soil age and cropping system and tillage practices. Where there are large differences, the land cannot usually be managed in the same way, more variation can be tolerated within an area that is extensively managed (e.g. in pastoral use) than in one that is intensively managed (e.g. for irrigated agriculture).
Variability is an important feature in the identification of soil properties related to crop production, irrigation scheduling, land drainage, land reclamation, run off and pollution, ground water contamination, liquid waste disposal from municipal, industries and so on. Some of them are known and can be described, many others are unknown. Soil variability thus seems random. Nevertheless, our task is to reveal at least some of these factors, and use the knowledge to design agricultural management practices that would be both environmental friendly and highly productive otherwise known as precision agriculture. A major motivation for research in soil variability is the need to make the best use of land, water and energy resources possible. Thus, this work focuses on the study of soil variability that can serve as important features in the identification of soil properties relatives to crop production, irrigation scheduling, land drainage and land reclamation as related to Oyo State College of Agriculture and Technology Teaching and Research Farm Igboora, Oyo State.

MATERIALS AND METHODS

The study was conducted on a three major toposequence at the Oyo State College of Agriculture and Technology Teaching and Research Farm, Igboora, located in Ibarapa Central Local Government Area of Oyo State Nigeria. It is located between 7° 15' to 7° 33' North, and 3° 56' to 3° 57' East. The high relative humidity favours the cultivation of crops such as a cowpea, maize, millet, cassava and yam. Igboora falls in the derived savanna agro-ecological zone of Nigeria; the area is characterized by adequate rainfall that spread for about seven months (mid-march – September) and dry period (October – May).

The study field has a total area of Ten hectares (10ha), the whole landscape was divided to three topographic positions for the purpose of this work, which are the summit or crest, lower slope and the valley bottom.

Transverse were cut and spaced at 50m apart at each delineated unit and points of observation were fixed at the intersection of the perpendicularly running transects, after this, soil with similar characteristics were grouped together as same mapping unit. Three soil profile pits were located and dug (1.5M x 1.5M x 2.0M) to represent each of the identified delineations (topographic positions) on the field. Altogether, a total of fifteen samples were collected from the three pits. The sample were air dried crushed and sieved to separate the fine earth fraction $\geq$ 2mm from coarser fragments using ceramic mortar and pestle with a 2mm sieve. Particle size analysis was determined using the modified Bouyoucous hydrometer method. Soil pH was determined in three suspension, using the procedure of pH in water, calcium chloride and potassium chloride. The available phosphorus was extracted with Olsen method (Emteryd, 1989) while exchangeable cations (Ca, Mg and K) were determined by flame photometry (Jackson, 1982).

The set of data from laboratory was analyzed statistically using Descriptive analysis for Mean (X), Standard deviation (SD) and coefficient of variation (CV) to find the level of variability. While critical level / range for some soil nutrient where used to determine the critical value/range. Correlation and regression analysis were done using SAS 2009 version. The variability of each property was measured by the coefficient of variation (CV) express as percentage. The higher the CV the more variable the properties.

RESULTS AND DISCUSSIONS

The soil reaction plays an important role in determining the solubility and reactively of soil elements such as Aluminium (Al), Manganes (Mn) and Cadium (Cd). The critical values for all the element is presented in table 1. The results of soil pH determined in a 1:2.5 soil to water and potassium chloride (KCl) suspension showed in coefficient of variation (CV) of 7.02% pedon-1, 10.52% pedon-2 and 7.22% pedon-3, table 2. This indicate that variability did occur within the three position on the same piece of land. This could be attributed to the type of vegetation cover and pattern of cropping system at the study area. Good tillage practice such as, pulverization of soil enhances microbial decomposition of organic matter and provides favourable conditions for microbial action. However, the total nitrogen was above the critical value /range according to rating by Sobulo and Osiname (1985). Available phosphorus of the studied pedons had Cv of 15.83% for pedon-1, 20.76% for pedon-2 and 14.26% for pedon-3; According to Adeoye and Agboola (1985) the available phosphorus of pedon-3 is below the critical range. With this result the lower available P at certain points on the top sequence could be due to some losses through plant uptake. Pedon and Krueger (1980), observed that some test for phosphorus and potassium had cyclic variation with season and that the degree of this variation increase with an increase in the rate of K and P fertilizer application. Available phosphorus was below critical level range as observed by Adeoye and Agboola (1985). Calcium increase with increase in organic matter and this explains the higher range of calcium observed in all pedons. However, the high variation shown by calcium could have been attributed to formation of calcium complexes which is still the effect of high soil organic matter. The exchangeable calcium was above critical level range as observed by Agboola and Corey (1973). The available iron CV in the studied pedons were 18.43, 10.37 and 18.87% respectively. The higher value of available iron in pedon-3 was attributed to high pH value which help indissolubility of more iron. According to Adeoye (1986) the value of the iron were all above the critical value/range. The available copper (Cu) had CV of 17.40, 23.24 and 11.09% respectively. The available manganese of the three pedons had CV of 14.60, 15.53 and 11.07% respectively, table 2. The highest value of manganese at pedon-2 could be attributed to lower slope that help to reduce the mobilization of Mg with water movement. The results of some soil chemical properties along top sequence in Teaching and Research Farm of Oyo State College of Agriculture and Technology, Igboora study site shows a complexity in variation. Soil pH, Ca and P where least variable while T.O.C, TN, K, Mg, Fe and Cu were variable. This must be taken into consideration for further stratification. The various soil region existing may require different management system for the same or different crops because of the basic differences in their characteristics. From the result obtained in the study, transfer of management methods adopted can be done for the slope of the upper regions but not for the lower region or the valley bottom.

Table 1: Critical Level/Range for some Soil Nutrients.

Element	Critical value/Range	Source
Total N (g/Kg)	15 – 20	Sobulo and Osiname (1985)
Available P (mg/Kg)	10 – 15	Adeoye and Agboola (1985)
Exchangeable k (Cmol/Kg)	0.01 – 0.15	Adeoye (1985)
Exchangeable Ca (Cmol/Kg)	2.0 – 2.6	Agboola *et al*., (1975)
Organic matter (g/Kg)	26	Sobulo and Osiname (1985)
Organic carbon (g/Kg)	15	Sobulo (1985)
ECEC (Cmol/Kg)	5	Adeoye and Agboola (1985)
Available Fe (mg/Kg)	5	Adeoye (1985)
Available Cu (mg/Kg)	1.9	Aderonmu (1988)
Available Zn (mg/Kg)	5 – 10	Adeoye and Agboola (1985)

Table 2: Showing the ranges, mean ($\bar{X}$), standard deviation (SD) and coefficient of variation (CV %) of the soil properties for the three (3) pedons examined

Soil properties	Pedon 1				Pedon 2				Pedon 3			
	$\bar{X}$	SD	CV	Range	$\bar{X}$	SD	CV	Range	$\bar{X}$	SD	CV	Range
pH H_2O	5.94	0.14	7.00	5.5-6.9	5.96	0.63	10.52	5.2-6.5	5.76	0.42	7.22	5.4-6.4
T.O.C (g/kg)	20.57	2.52	12.23	17.73-24.17	19.46	2.20	11.34	16.62-21.04	17.63	4.93	27.98	11.17-23.15
TN (g/kg)	0.94	0.32	33.78	0.46-1.18	0.83	0.33	40.07	0.45-1.15	0.78	0.41	52.90	0.12 – 1.12
Av. P (Mg/kg)	8.03	1.27	15.83	6.11-9.11	6.98	1.45	20.76	5.28 – 8.36	5.40	0.77	14.26	5.11 – 6.16
Exch Acidity	0.14	0.05	39.12	0.1-0.14	0.12	0.04	37.26	0.1 – 0.12	0.18	0.04	24.84	0.1 – 0.18
Ca (Cmol/kg)	25.05	4.96	19.82	18.3-31.2	20.51	1.92	9.37	18.3–23.56	21.68	2.78	12.85	19.36 – 26.5
Mg (Cmol/kg)	1.92	0.35	26.95	0.98-1.68	1.77	0.15	9.23	1.55 – 1.96	1.61	0.20	12.28	1.6 – 1.86
K (Cmol/kg)	0.45	0.13	28.74	0.6-0.58	0.35	0.13	36.98	0.18 – 0.43	0.32	0.21	37.03	0.14 – 0.43
Na (Cmol/kg)	1.12	0.20	17.88	0.93-1.43	0.95	0.08	8.50	0.88 – 1.06	0.87	0.18	20.27	0.9 – 1.15
Mn (Mg/kg)	34.42	50.60	14.60	298.5-387.6	322.7	50.13	15.53	288 – 322.7	375.34	43.92	11.70	322.1– 423.5
Fe (Mg/kg)	58.18	10.73	18.43	46.5-71	44.58	4.63	10.37	38.5 – 46.5	36.76	6.93	18.87	29.8 – 46.5
Cu (Mg/kg)	1.14	0.20	17.40	0.9-1.41	1.54	0.36	23.24	1.11 – 1.93	1.35	0.15	11.09	1.18 – 13
Zn (Mg/kg)	1.52	0.30	19.90	1.1-6.4	1.51	0.27	17.95	1.15 – 1.86	1.98	0.23	10.85	1.66 – 2.22

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EFFECT OF MICRO-SIZE BIOCHAR ON REMEDIATION OF HEAVY METAL IN DUMPSITE SOIL

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ABSTRACT

A pot experiment on 'Effect of micro – size biochar on remediation of heavy metal polluted dumpsite soil' was conducted to assess the use of micro – size biochar for remediation of heavy metals. The experiment consisted of three rice husk micro – size (1.00, 1.50 and 2.00mm) as treatments. The experiment was laid out in completely randomized design (CRD) in the screen house and replicated three times. Data was collected on the heavy metals before treatment application and after harvesting of test crop (Maize) and the result analyzed using GENSTAT. The result revealed that, dumpsite soil studied was contaminated with heavy metals. The largest quantity of heavy metal present was Zinc (4.749 mg/kg); followed by Mercury (2.556 mg/kg); Manganese (2.108 mg/kg); Chromium (1.111 mg/kg); Iron (1.044 mg/kg); Nickel (0.192 mg/kg); Cupper (0.156 mg/kg); Lead (0.117 mg/kg) and the lowest was Cadmium (0.051 mg/kg). The heavy metals in the dumpsite soil is presented in ascending order of concentration as: Cd < Pb < Cu < Ni < Fe < Cr < Mn < Hg < Zn. Application of 2mm size nano-sized biochar adsorbed the lowest amount of heavy metals: Zinc (0.01mg/kg); Mercury (0.01mg/kg); Manganese (0.01mg/kg); Chromium (0.01mg/kg); Iron (0.01mg/kg); Nickel (0.01mg/kg); Cupper (0.02 mg/kg); Lead (0.02 mg/kg) and Cadmium (0.01 mg/kg). It can be concluded that the dumpsite soil contained heavy metals in ascending order of concentration as: Cd < Pb < Cu < Ni < Fe < Cr < Mn < Hg < Zn and 1mm size of micro-size biochar adsorbed high concentration of these heavy metals in the dumpsite soil.

Keywords: *Micro-size, Biochar, Heavy metal, Dumpsite and Remediation*

INTRODUCTION

Remediation of heavy metal polluted soils is usually carried out by conventional practices; which include excavation and land filling. This is usually not feasible on large scale, because these techniques are cost-prohibitive and environmentally disruptive (Arthur *et. al.,* 2005). However, recent studies by these scientists (**Beesley *et.al,* 2011;** Ndor *et.al,* 2016a; Noreen and Abd-Elsalam, 2021), reported that soil amendment with biochar reduced the bioavailability of a wide range of heavy metals, potentially reclaiming contaminated soils for agricultural use. Biochar is a solid carbonized product obtained from biomass feedstock such as agricultural waste and other lignocellulosic materials by the controlled process of thermal decomposition in the absence (pyrolysis) or limited oxygen (Lehmann and Joseph 2015). In recent years, carbon nano-materials have been developed as powerful tools; due to their unique characteristics and number of applications in various areas like: energy, materials science, agriculture and the environment. Nanobiochar technology may result in production of carbon-based nano-materials known as nano-biochar; which serve as advanced nanostructured biochar that have come up with the sustainable solutions for a range of soil problems of modern era (Lateef *et al.,* 2019). Nanobiochar is nanosized biochar material with better physical, chemical and surface properties. Therefore, the decreasing particle size in micro range (10–600 μm) of biochar always led to increased available sites for adsorption, thus resulting in better adsorption capacity (Lonappan *et al.,* 2016). Further reduction in size of biochar particles to nano-size was reported by Naghdi *et al.,* (2019) to enhance its properties of higher surface to volume ratio, increased surface energy, increased adsorption potential and consequently biological effectiveness. Hence, nanobiochar is trending these days as it amalgamates the advantages of nanotechnology with biochar technology. Therefore, the objective of the study is to assess the use of micro – size biochar for remediation of heavy metals on dumpsite soil in Nasarawa State

MATERIALS AND METHODS

Experimental Site

The experiment was conducted during the rainy season of 2022 at the screen house of College of Agriculture, Science and Technology, Nasarawa State. The study area falls within southern guinea savanna agroecological zone of Nigeria. Rainfall period is usually from March – October and the average monthly rainfall figures of 350 mm. The months of July and August usually record heavy rainfall. The daily maximum temperature ranges from 20.0°C– 38.5°C and daily minimum ranges between 18.7°C–28.2°C. The months of February to early April are the months that have the highest maximum temperature; while the lowest maximum temperature are recorded in December and January because of the prevailing cold harmattan wind from the northern part of the country at this period. The relative humidity rises from April to a maximum of about 75- 90 percent in July (NIMET 2022).

Treatment and Experimental Design

The pot experiment consisted of three rice husk micro – sized biochar (1.00, 1.50 and 2.00mm) laid out in completely randomized design (CRD) and replicated three times.

Soil Sample Collection/Preparation

The dumpsite soil was collected at a depth of 0-20cm in the month of April, 2022 at an old abandoned dumpsite in Al-makura street in sabon-pegi Lafia; Nasarawa state. This period was chosen for sample collection because rain had not started, so infiltration is restricted. Due to the fact that soils vary intrinsically, soil samples were obtained through random sampling in three different spots on the same dumpsite, bulked together to form a composite sample. The composite sample was air dried in the laboratory and sieved through a 2 mm mesh.

Soil Analysis

The composite soil sample was analyzed for heavy metal before maize was planted. Soil samples were again collected after the harvest of maize cobs from each of the treatments for analysis. 100g from each soil sample in the 9 buckets were transferred into different 250 ml standard flask, diluted with 50 ml of 2M HNO_3 and then heated in the sand bath for about 3 hours at a temperature of 900 C to 1000 C. The digested solution was evaporated to near dryness and allowed to cool to room temperature. It was then filtered into standard flask, diluted to 100 ml with distilled water and shaken vigorously. Subsequently, it was poured into 120 ml plastic bottle prior to aspiration into the Atomic Absorption Spectrophotometer (Perkin Elmer) to determine the metals. Settings and operational conditions were followed with respect to the manufacturer's guidelines.

Production of rice husk micro - size biochar

Rice husk was collected from Lafia rice mill for the production of parent biochar. An improvised kiln was constructed using an empty drum that was perforated but had a cover. The rice husk material was poured inside the drum to half full, then ignited inside the drum. More rice husk material was added, the drum lid was covered to encourage slow burning and the content in the drum was consistently stirred to enhance uniformity of burning. After 3-4 hours the content of drum was poured out, the fire quenched with water (by sprinkling water on the hot char) and dried in the sun for 2 days (Ndor *et al.*, 2016). Then, the bulk parent biochar produced using rice husk is mechanically ground using pestle and mortar; then sieved into micro-size biochar using different sizes of the sieve according to the treatments.

Pot Experiment

A total of nine plastic buckets were filled with 5kg of the sieved composite dumpsite soil. After filling the plastic bucket with dumpsite soil, treatments were incorporated into the plastic bucket. Sammaize 15 variety of maize was used as test crop.

Data Collection

The following heavy metals (Cd, Pb, Cu, Ni, Fe, Cr, Mn, Hg and Zn) were analyzed before sowing and after harvesting of the test crop (maize).

Data Analysis

The data collected were subjected to analysis of variance using GENSTAT, and where there is a significant difference; the means were separated using F-LSD at 5% probability level.

RESULTS

Concentration of heavy Metals in Dumpsite soil

The result in Table 1 showed that the dumpsite soil studied was contaminated with heavy metals. The largest quantity of heavy metal present was Zinc (4.749 mg/kg); followed by Mercury (2.556 mg/kg); Manganese (2.108 mg/kg); Chromium (1.111 mg/kg); Iron (1.044 mg/kg); Nickel (0.192 mg/kg); Cupper (0.156 mg/kg); Lead (0.117 mg/kg) and the lowest was Cadmium (0.051 mg/kg). The heavy metals in the dumpsite soil is hereby presented in ascending order of concentration as: Cd < Pb < Cu < Ni < Fe < Cr < Mn < Hg < Zn.

Table 1: Concentration of heavy metals in dumpsite soil

Heavy metal (mg/kg)	WHO Standard	Mean	Mini	Maxi	SD	SE	%CV
Cd	0.8	0.051	0.002	0.280	0.047	0.008	92.137
Cu	36	0.156	0.056	0.282	0.063	0.010	40.421
Cr	100	1.111	0.001	2.498	0.623	0.100	56.081
Fe	150	1.044	0.450	1.440	0.263	0.042	25.168
Hg	NA	2.556	1.710	4.194	0.906	0.145	35.421
Mn	NA	2.108	1.170	3.064	0.561	0.090	26.604
Ni	35	0.192	0.030	0.720	0.231	0.041	76.252
Pb	85	0.117	0.001	0.560	0.091	0.015	78.021
Zn	50	4.749	3.683	5.127	0.385	0.062	80.104

Effect of micro-size rice husk biochar on remediation of heavy metal in the dumpsite soil

The result in Table 2 showed a significant ($p< 0.05$) decreased in bioavailability of all the heavy metals assessed in dumpsite soil after the harvest of test crop. Application of 1mm sizes of micro-size biochar adsorbed higher concentration of cadmium, copper, manganese, nickel and zinc in the dumpsite soil; and this is statistically at par with the application of 1.5mm size micro-size biochar. However, application of 2mm size micro-size biochar adsorbed the lowest amount of heavy metals: Zinc (0.01mg/kg); Mercury (0.01mg/kg); Manganese (0.01mg/kg); Chromium (0.01mg/kg); Iron (0.01mg/kg); Nickel (0.01mg/kg); Cupper (0.02 mg/kg); Lead (0.02 mg/kg) and Cadmium (0.01 mg/kg).

Table 2: Effect of Nano-sized biochar and rates of application on remediation of heavy metal in dumpsite soil after harvest of maize

Treatments Nano biochar	Cd	Cu	Cr	Fe	Hg (mg/kg)	Mn	Ni	Pb	Zn
Size (mm)									
1.00	0.07	0.17	1.23	1.24	3.08	2.42	0.08	0.16	4.91
1.50	0.06	0.19	0.56	1.04	2.43	2.21	0.07	0.11	4.90
2.00	0.04	0.10	0.55	0.88	1.80	1.83	0.05	0.08	4.71
LSD(0.05)	0.01	0.02	0.01	0.01	0.01	0.10	0.01	0.02	0.01

DISCUSSION

The dumpsite soil used for this study was really contaminate with heavy metal. This result is in agreement with the findings of other earlier works like Esakku *et al.* (2003), who reported that heavy metals were always the major concerns at municipal dumpsites. Also, Umoh and Etim (2013) who worked on soils from dumpsites within Ikot-Ekpene in Akwa-Ibom State, Nigeria discovered that the increased in the concentration of the heavy metals in the soils from the areas could be attributed to different sources like: automobile exhaust fumes, dry cell batteries, sewage effluents, runoff from other solid wastes garbage. Finally, Asawalam and Eke (2006) and Njoku and Ayoka (2007) also investigated the trace metal concentrations and heavy metal pollutants from dump soils in Owerri, Nigeria observed that though these heavy metal concentrations fell below the critical permissible concentration level, it seems that their persistence in dumpsite soils may lead to increased uptake of these heavy metals by plants.

The positive response of micro – size biochar to remediation of various heavy metals in dumpsite soil in this study corroborates with the findings of Ma *et al.* (2019) who reported that nanobiochar exhibited outstanding adsorption capability owing to its unique characteristics. Hence, nanobiochar has been considered to be a promising agent for bioremediation of a wide variety of contaminants in the soil. Also, Liu *et al.* (2020) who worked on remediation of cadmium contaminated soil using micro size biochar reported a significant decreased in bioavailability of Cd in the soil. It has also been proven by several other researchers (Yu *et al.*, 2015; Wang *et al.*, 2015 and Wang *et al.*, 2018) that nanobiochar contain huge capacity to remove major heavy metal contaminants including arsenic, lead, copper, chromium, cadmium etc in the soil.

CONCLUSION

In conclusions, this study revealed that the dumpsite soil contained heavy metals in ascending order of concentration as: Cd < Pb < Cu < Ni < Fe < Cr < Mn < Hg < Zn. Then, 1mm size of micro-size biochar adsorbed high concentration of these heavy metal (cadmium, copper, manganese, nickel and zinc) in the dumpsite soil after harvest of the test crop.

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COMPARATIVE ANALYSIS OF RAIN-FED AND IRRIGATED RICE PRODUCTION IN SELECTED LOCAL GOVERNMENT AREAS IN YOBE STATE, NIGERIA

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ABSTRACT
This research study focused on comparative economic analysis of rice production under irrigation and rain-fed systems in Yobe State, Nigeria. Primary data were collected from Eighty (80) respondents with the use of well structured questionnaire. Data were analysed using gross margin analysis, and stochastic production frontier model. The result revealed that gross margin realized by the irrigated and rain-fed farmers were ₦137,189.90 and ₦355,625.64 respectively. The net profit obtained by irrigated farmers was ₦76,979.79, while rain-fed farmers realized ₦327,892.66 with gross margin ratios of 0.44 and 0.77 respectively. Also, the estimates of the factors influencing the total output of rice production among the farmers under irrigated and rain- fed systems showed that seed, farm size, fertilizer, chemical, family and hired labour are statistically significant at different level. Furthermore, the study shows that rice farmers under both systems were faced with the following constraints; high cost of transport, lack of storage facilities, inadequate finance, bad roads, excessive rainfall, flooding and high cost of inputs. The research concluded that rice production is profitable though irrigated system is more viable. The study recommended that extension services should be intensified to improve technical know-how and capacity of the rice farmers.
Keywords: *Comparative, Rice, Production, Stochastic, Nigeria*.

INTRODUCTION
Rice (*oryza sativa*) is the staple food in Nigeria that is produce and consumed in all regions in the country. With the growing population in Nigeria, rice production is strategic as it plays a key role in the provision of food and employment as well as enhances every famer's income and food security (Adeleye *et al*., 2020). Nigerian is the highest consumer of rice in West Africa and highest producer in Africa as well as one of the leading importers of rice in the world (Soullier *et al*., 2020). This was due to continuous increase in population, preference of people, change in income, urbanization that has made the demand to grow at geometric proportion. The amount of land available for rice production in Nigeria was reported to be about 6 million hectare of land but only 3.2 million hectares were used for rice production, producing about 3.7 million tons of rice per year while the total demand for rice in 2018 was about 6.4 million tons (FAOSTAT, 2018). This implies that the land area for rice production is not totally covered by cultivation which means that only half of the specified land is under cultivation. The deficits of over 2.8 million tons of rice were being imported to Nigeria.

Rice production as a major source of employment and nutritional support to household and the nation with attendance issues should not be neglected. Efforts have been directed on various researches aimed at addressing rice production and sufficiency at different researches in Yobe State. Some of which include resource used efficiency of rice production (Madaki *et al*, 2022), effect of importation ban on rice production, women participation in rice production, environmental impacts on rice production (Bukar et al, 2021) ,effect of malaria on crop production in Yobe State (Madaki, 2017), among others. Little or no attempt has been made on comparative analysis of rain fed and irrigation system of rice production in the State. Hence, the research work intends to carry out comparative analysis of rain fed and irrigated rice production in Yobe State. The specific objectives are to;

(i) compare costs and returns of rice production under irrigation and rain-fed system in the study area,

(ii) determine the factors influencing technical efficiency of rice farmers under irrigation and rain-fed systems in the study area,

METHODOLOGY

Yobe State lies on coordinate latitude 12°, 00N and longitude 11° 30E with an estimated area of 45,502 km². The total population according to the census 2006 was 2,321,399 and it was estimated to be about 4,000, 000 in 2021 (NPC, 2022). A multi-stage sampling procedure was employed for the study. The sample matrix is shown in Table 1 below. Primary data were collected and used for this study. Primary data were obtained through administration of well-structured questionnaire that was administered by the researcher and with the help of extension officers and well-trained enumerators. Data were analyzed using gross margin analysis, and stochastic production frontier model.

Table 1:Sampling Frame and Sample Size of Rice Farmers in the Study Area

S/N	LGA's	Wards	Sample Frame		Proportion		Sample Size		Total Sample
			Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	
1	Bade	Dagona	25	37	0.067	0.099	2	4	8
		Katuzu	35	45	0.194	0.121	7	5	12
		Gwio-kura	26	40	0.070	0.107	2	4	6
		Tagali	47	35	0.127	0.094	6	3	9
		Usur	40	55	0.108	0.147	4	8	12
2	Geidam	Ashelkri	33	20	0.089	0.054	3	1	4
		Hausari	30	31	0.081	0.083	2	3	5
		Kusur	50	34	0.135	0.091	7	3	10
		Dejina	50	40	0.135	0.107	7	4	11
		Dilawa	35	26	0.194	0.069	3	2	5
	2	**10**	**371**	**373**	**1**	**1**	**43**	**37**	**80**

Source: Field Survey, 2022.

Gross margin Model (GM) is stated thus.

$$GM = TR - TVC \dots\dots (1)$$

$$GM = \sum_{i=1}^{n} P_i Q_i - \sum_{i=1}^{n} P_j X_j \dots\dots (2)$$

Where, GM = Gross Margin (₦/ha);
TR= Total Revenue from the sales of rice harvested under irrigation and rain fed systems (₦);
TVC= Total Variable Cost (₦).
P_i = Price of rice in (₦/Kg)
Q_i = Total quantity of rice produced under irrigation and rain fed system (Kg/ha)
P_j= Price of Input (₦/Kg)
X_j = Quantity of Input Used (Kg/ha).

Stochastic Production Frontier Model.

This study applied stochastic production frontier function model developed by Sanusi et *al*., (2022). It is stated thus;

$$Y_i = f(X_i, \beta)\epsilon, i = 1, \dots, N \dots\dots\dots\dots (5)$$

Where
The Stochastic Frontier Model is stated thus

$$Y_i = F(X_i, \beta) + \epsilon_i \dots\dots\dots\dots\dots\dots\dots\dots (6)$$

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, V - U_i) \dots\dots\dots (7)$$

$$LnY_i = \beta_0 + \sum_{i=1}^{6} \beta_i LnX_i + \cdots \beta_n LnX_n + V - U_i \dots\dots\dots\dots\dots\dots\dots (8)$$

The explicit function is stated thus:

$$LnY_i = \beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3 + \beta_4 LnX_4 + \beta_5 LnX_5 + \beta_6 LnX_6 + V_i - U_i. (9)$$

Where,
LnY_i = Output of rice (Kg)
X_1= Seed Input (Kg)
X_2= Farm Size (Hectares)
X_3= Quantity of Fertilizer NPK(Kg)
X_4= Agrochemical Inputs (Litres)

X_5 = Family Labour Input (Mandays)
X_6 =Hired Labour (Mandays)
β_0 = Constant Term
$\beta_1 - \beta_6$ = Parameters to be estimated
Ln =natural log
Vi =error term
The Technical Inefficiency Component of the Stochastic Frontier model is stated thus:

$$U_i = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \alpha_6 Z_6 + \alpha_7 Z_7 + \alpha_8 Z_8 + \alpha_9 Z_9 \alpha_{10} Z_{10} \alpha_{11} Z_{11} \dots\dots\dots\dots\dots\dots (10)$$

Where,

$$U_i = Technical\ Inefficiency\ Component$$

Z_1= Age of Farmers (Years)
Z_2= Education Level of Farmers (Years).
Z_3= Household Size (Number)
Z_4= Farm Experience (years)
Z_5= Non-Farm Income (Naira)
Z_6= Amount of Credit (Naira)
Z_7 =Frequency of Extension contact (number of contact per day)
Z_8= Access to Price Information (1, Yes;0, Otherwises)
Z_9 = Total Revenue from sales of rice produce (Naira)
Z_{10} = Unit Price of rice (Naira/kg)
Z_{11} = Membership of Cooperative Association (1, Yes;0, Otherwise)
α_0 = Constant Term
$\alpha_1 - \alpha_{11}$ = Regression Coefficients
This was used to achieve specific objectives two (ii) which is to determine the technical efficiency of rice farmers under irrigation and rain-fed systems.

RESULTS AND DISCUSSION

Costs and Returns of Rice Production under Irrigated and Rain-fed System among Farmers in the Study Area

The analysis of costs and returns involved in rice production under irrigated and rain-fed system among farmers in the study area as presented in Table 2. The study revealed that, the total variable cost incurred by rice farmers under irrigated system was ₦127,347.66, while the total variable cost incurred by rice farmers under rain-fed system was ₦105,001.28, the variable cost 68% and 79% out of the total cost of rice production under irrigated and rain-fed systems respectively. This result is in agreement with Akinbode (2013), who reported that the total variable costs (TVC) dominated the production cost of rice farmers, with 84.43% of the total production cost, while total fixed cost (TFC) explained the remaining 15.57% of the total production cost in rice production under irrigation system. Estimated cost of family labour has the highest value out of the variable cost in both irrigated and rain -fed systems with a percentage of 28% for irrigated system and 56% for rain fed system respectively. This is in line with the findings of Oloyede *et al*., (2021) who reported that family labour costs rated highest with total of 68.92%, this is followed by hired labour cost, which rated 59.25%.

Estimates of the Factors Influencing Technical efficiencies of Output of Rice Production among Sampled Farmers under Irrigated and Rain-fed Systems in the Study

The results of the maximum Likelihood estimates (MLE) of the parameters of the stochastic frontier production function and technical efficiency and inefficiency component for rice farmers under irrigated and rain-fed systems (Table 3). The estimate of gamma is a measure of the level of the inefficiency in the various parameters and its values ranges from 0 to 1. Gamma estimates was 0.30 and 0.0022 indicating the presence of technical inefficiencies among irrigated and rain-fed systems among rice farmers in the study area. This result can be interpreted that 30% and.0.22% of the random variations in the output of rice among farmers under irrigated and rain- fed systems was due to differences in technical inefficiencies. The estimated coefficient of chemical usage among irrigated and rain fed system were 0.7705 and -0.3556 and are positively and negatively statistically significant at (P<0.01) and (P<0.10) respectively. This implies that a percentage increase in quantity of chemical applied to rice by farmers under irrigated system will result in 77% increase in the total output of rice production among farmers under irrigated system and -10% decreases in technical inefficiency in ran fed farmers.

Table 3 Maximum Likelihood Estimates of the Stochastic Frontier of Rice Production Function for Irrigated and Rain-fed Systems in the Study Area

Variable	Irrigated System			Rain-fed System		
	Coefficients	Std Error	Z-Score	Coefficients	Std Error	Z-Score
Seed input	.9197600	.2246395	4.4*	.153018	.2862165	0.53
Farm size	.0695355	.12318	0.56	.3177182	.1221348	2.60**
Fertilizer	-.0520878	.0479665	-1.09	.1703302	.1001697	1.70***
Chemical	.7705953	.1885314	4.09*	-.3556807	.2018589	-1.76***
Family labour	.2810771	.1057705	2.66**	.1764158	.1127985	6.78*
Hired labour	.4302047	.1042601	4.13*	.1607776	.1250305	1.29
Constant	.0356178	.4866704	0.07	.3712768	.6059639	0.61
Inefficiency Model						
Age	-.00884	.001196	-6.69*	.0032871	.0037954	0.87
Level of education	-.0004505	.0001812	-2.49**	-.0368875	.0211693	-1.74***
Household Size	-.0011589	.0000353	-32.87*	-.0122145	.0066237	-1.84***
Farm Experience	.0000597	.0000752	0.79	-.0094899	.0042113	-2.25**
Non-Farm Income	2.42e-08	6.64e-09	3.65*	-.070021	.0765324	-0.91
Access to Credit	2.46e-09	3.34e-09	0.74	-.1763348	.0866274	-2.04**
Extension contact	-.003756	.0001438	-26.12*	-.0851234	.1055133	-0.81
Price Information	.0077702	.0015146	5.13*	-.1894005	.104735	-1.81***
Total Revenue	2.58e-10	4.82e-10	0.53	-1.20e-07	6.42e-08	-1.87***
Unit Price	-.3556807	.2018589	-1.76***	3.48e-06	3.75e-06	0.93
Coop Association	-.056685	.0029234	-19.51*	-.2805139	.1112297	- 2.52**
Diagnostic Statistics						
Log likelihood	3.4406017			834.785		
Sigma square	.0520599			.0565401		
Gamma	.3003506			.0022177		

Source: Field Survey Data (2022).
Note: *Significant at 1%, ** Significant at 5%, * Significant at 10%**

CONCLUSION

The study concluded that rice farming under irrigated and rain-fed system in the study area was a profitable enterprise. The farmers were more into rain-fed system of rice farming than irrigation farming, because of the high cost of investment capital on equipment's and lack of technical know-how and skills. Rain-fed rice production is more profitable in rainy season, while irrigation production is more profitable in dry season in the study area. Further the studied concluded that seed input and hired labour are significant factors of efficiency on irrigated farms while farm size is a significant factor in rain fed. Inefficiency factors of common to both irrigated and rain fed include level of education, household size and cooperative association. The demand for rice is applicable to both seasons; therefore, increased production is necessary throughout the year to meet up with demand of the citizenry in the study area and beyond. Based on the findings emanating from the research, the study recommends as follows;

(i) There should be efforts aimed at reduction in inefficiency level of the rice farmers through extension services training, and capacity building to improve their technical know-how. This will enhance efficiency in production..

(ii) Government and non-governmental organizations should enhance infrastructural facilities in the rural areas. This will curb the high cost of transportation owning to poor road networks.

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DETERMINANTS TO INTENSITY OF FERTILIZER USE BY YAM FARMERS IN ANAMBRA STATE, NIGERIA

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ABSTRACT
Determinants to intensity of fertilizer use by yam farmers in Anambra State, Nigeria was studied. 120 respondents were selected or the study using multistage random sampling technique. Primary data were obtained using questionnaire and oral interview. Percentages responses and ordinary least squares were used to analyze the objectives of the study. Compound fertilizer was the most important fertilizer used in the study area. Also, educational level, household size and membership of organization were the determinants to intensity to fertilizer use in the area. The need to enhance the farmers' access to educational programmes and as well, encourage farmers to form or join cooperatives were recommended
Keyword: *Determinants, Intensity, Fertilizer use, Yam farmers*

INTRODUCTION
Sub-Saharan Africa faces huge food supply challenges due to among others declining yields associated with continuously declining soil fertility (Amanze, Eze, and Eze, 2010). Among the crops grown by the smallholder farmers in the region is yam. It is one of the principal tuber crops in the Nigeria economy, in terms of land under cultivation and in the volume and value of production (Ume Kaine and Ochiaka 2020). Yam is one of the major staple food in Nigeria and has potential for livestock feed and industrial starch production (FAO, 2020). Nigeria is the largest producer of yam in the world (67% of global output), with an annual production of 44.1 million tonnes (IITA, 2020). To improve food security, farmers use inorganic fertilizers in compensating for soil nutrients loss caused by intensive cultivation practices, soil erosion and among others (Kelly, 2006).
Despite the fertilizer subsidy by the Anambra State government in order to boost fertilizer technology adoption by farmers to enhance their crop productivity, empirical studies show that the intensity of use of this soil amendment in recent time is not encouraging. For instance, according to Amanze, Eze and Eze, (2010) fertilizer use rate among farmers in the Nigeria was far below the 200 kg/ha recommended by Food Agriculture Organization (FAO) for the sub- Sahara African countries. Therefore, following the current situations of low growth rate of arable crop outputs, rapid population growth and unintended objective from the highly publicized fertilizer subsidy programme in the state; there is need to identify the factors impeding optimum used of fertilizer among yam farmers in the State. Specifically, the objectives of the study are to, describe the socioeconomic characteristics of respondents, identify types of fertilizer and determine factors that affect fertilizer use intensity among respondents in the study area.

MATERIALS AND METHODS
The study is carried out in Anambra State of Nigeria. Anambra State is located between latitude $5^0$38 'N and $6^0$47 'E of Equator and longitude $6^0$36 'N and $7^0$21 'E of Greenwich Meridian. The state is bounded in the East by Enugu State, in the West by Delta State, in the South by Imo State and in the North by Kogi State. Anambra State has projected population figure of 6,317,840 million people (NPC, 2023).The non-agricultural activities involved by Anambra people are trading, vulcanizing, barbing and tailoring

Sampling Technique and Sample Size
A multi-stage random sampling technique was used to select Local Government Area (LGA), towns and processors. In the first stage, twelve LGA were purposively selected out of seventeen. The selection was based on intensity of yam production. In the second stage, ten towns were randomly selected from each LGA. These brought to a total of one hundred and twenty towns. In the third stage, one yam famer was selected from each towns from

the lists of farmers provided by the extension agent residing in the towns. This brought to a total of one hundred and twenty yam farmers for detailed study.

Method of Data Collection

Structured questionnaires and informal or oral interview were used to collect primary data.

Method of Data Analysis

Fertilizer use intensity (FUI) as defined by Olayide, Arega and Ikpi., (2009) was described as follows:

$$FUI = \frac{\text{Quantity of fertilizer used by } i_{th} \text{ farmer measured in Kg}}{\text{Area of land cultivated by } i_{th} \text{ farmer measured in hectare}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

The Logit regression model is used to determine factors influencing fertilizer use intensity among yam farmers in the study area. This is mathematically stated thus:

$L1 = In [p1/1\text{-}p] = \beta o + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \beta 5X5 + \beta 6X6 \ldots\ldots\ldots\ldots \beta nXn \ldots\ldots(2)$

Where Pi = 1 if respondent had high intensity of fertilizer use, Pi = 0 if respondent had low intensity. .

This could be represented explicitly as

$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}, X_{11} + e) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$

X_1 = age of a farmer (years), X_2 = years of formal education of farmers (years), X_3 = household size of farmer (number), X_4 = off farm income by farmers (1=Yes and 0 otherwise), X_5 = purpose of crop grown by farmer (1= commercial crop, 0 = otherwise), x6 = perceived price of fertilizer by farmers (1= high price and 0= low price), X_7 = distance to fertilizer selling point (1 = far, 0= otherwise), U = stochastic error term.

RESULTS AND DISCUSSION

Table 1 Distribution of respondents according to socioeconomic characteristics

Age		
20 – 40	45	37.5
41 – 72	75	62.5
Household Size		
1- 10	80	66.67
11 – 20	40	33.33
Farm Size		
Less than 2ha	48	40
Above 2 ha	72	60
Educational Level(Years)		
No Formal	32	26.67
Primary	48	40
Secondary	30	25
Tertiary	10	8.33
Price of fertilizer(Dummy		
High	80	66.67
Low	40	33.33
Purpose of crop cultivation		
Commercial	86	71.67
Subsistence	34	28.33
Organization membership		
Yes	54	45
No	66	55
Distance to fertilizer selling point		
Far	68	56.67
Near	52	43.33

Source: Field Survey, 2018

Table 1shows that most farmers (37.5%) were below 40years of age, while 62.5 % were above 40 years. Aged people are very conservative to engage in committing substantial resources, especially costlier ones like fertilizer in farming for fear of failure (Olayide, *et al;* 2009). More so, 66.67% of the sampled farmers had household size of 1– 10 people, while 33.33% had 11 persons and above. Household head with large dependents members may not be able to have money to procure as much fertilizer that could be needed in his farming activities, thus underutilizing the resource (Chnu and Tsuji, 2004). Table 1 shows that 73.33% of the sampled farmers had formal education, while 26.67% had no formal education. The higher the educational attainment of the farmer, the high propensity of harnessing the benefits of the use of improved inputs such as fertilizer in crop production. As well, most (60%) of the sampled farmers had farm size ranging from above 2 hectares, while 40% had less than 2 hectares. Empirical studies show that farmer with large farm holdings has high intensity in fertilizer use than their counterpart with small farms (Ume; *et al;* 2020). Also, 66.67% of the respondents perceived price of fertilizer to be high, whereas, 33.33% do not. The higher the cost of fertilizer, the lower the intensity of fertilizer use and vice versa (Amanze; *et al;* 2010) More so, 56.67% of the respondents reported that distance to source of the fertilizer was barrier to intensity of fertilizer use. The high price of fertilizer coupled with high transport fares from procuring point could determine the intensity of its (fertilizer) use. Additionally, most (28.33%) respondents grow yam for subsistence, while 7.67% grow for commercial purpose. When farmers grow for commercial purpose, the use intensity of fertilizer is higher than for subsistence. More so 45% of the respondents were members of social organization such as cooperative, while55% were not. Cooperative members, for instance through interaction among themselves could boost their intensity of fertilizer use (Ume, Uloh, Nnadozie, and Nnaji, 2020).

Table 2.Types of Fertilizer used by the farmers.

Variable	Frequency	Percentage
Compound Fertilizer	102	85
Muriate fertilizer	24	20
Single super phosphate	15	12.5
Urea	12	10
Commercial fertilizer	54	45

*Multiple Responses.
Source, Field Survey, 2022

Most (85%) of the respondents used compound fertilizer, which could be inform of complete(Contains Nitrogen, Phosphorus and Potassium.(NPK) and balanced fertilizers (contain equal nutrient amounts, such as a 10-10-10) for high crop output (IITA 2020). The least (10%), was urea fertilizer. Urea has intrinsic quality of providing nitrogen at the lowest cost, has NPK ratio of 46-0-0 and may be mixed with other fertilizers or may be applied alone, hygroscopic in nature and highly soluble in water (FAO 2020).

Table 3 Socioeconomic factors affecting intensity of fertilizer use

Variable	Coefficient	**Standard Error**	t-value	P>|t|
Age	- 0.02500	0.00944	- 2.63*	0.130
Educational level	0.96430	0.33412	2.89**	1.003
Household size	0.43220	0.13652	3.14***	0.007
Organization	0.5522	0.22721	2.42**	0.006
PCG	0.22321	0.32726	0.868	0.019
PPF	0.36452	0.24724	1.748*	0.021
DFSP	0.11722	0.20720	0.566	0.003
Constant	8.097321	2.00981	4.03***	0.021
Sigma	1.46786	0.36722		
Number of Observation	120			
Log likelihood	-722076			
LR chi2	184.59***			
Pseudo	0.3652			

Source; Field Survey, 2022
***, **, * are significant levels at 1.0%, 5.0% and 10.0% respectively. NB. PCG = Purpose of crop grown, PPF = Perceived price of fertilizer, DFSP = Distance to fertilizer selling point

The coefficient of age of farmer had negative relationship with intensity of fertilizer use. The negative sign identity of the coefficient of age could be related to conservative attitude of aged farmers to adoption of technology, hence could affect their intensity of such technology use (Chinu and Tsuji, 2004). Additional, the educational level coefficient was positive and significant to fertilizer use intensity. Educational status of the farmer enhances his /her judicious use of resource, fertilizer use intensity inclusive in order to boost their farm outputs and as well to conserve possible degradation of the environment as result of the resource use (Ume, *et al;*2020). Also, the coefficient of household size was positive and significant at 1% probability level. Household heads with large family size are more proxy of using cheap family labour to enhance fertilizer use intensity in their farms compare to those with small household members (Ume, Kaine and Ochiaka 2020). More so, the coefficient of organization was positive and significant at 5% probability level. Farmers that are members of organization using have easy access to agricultural information, training, credit and other production inputs, hence enhances their rate of fertilizer use (IITA 2020) As well, the perceived prices of fertilizer coefficient had negative relationship with intensity of fertilizer use and significant at 10%. The sign identify of the coefficient could be related to the fact that farmers restore to minimal fertilizer application compare to standard requirement, leading to meagre crop yield (Kelly, 2006).

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INFLUENCE OF PLANTING METHODS AND WEED MANAGEMENT ON GROWTH AND YIELD OF RICE (*ORYZA SATIVA* L.) IN BADEGGI AND LAFIA, NIGERIA.

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ABSTRACT
A multi-locational field experiment was conducted during the cropping seasons of 2022 at the Teaching and Research Farm of the Faculty of Agriculture, Nasarawa State University, Keffi Shabu-Lafia Campus and at the National Cereals Research Institute Baddegi Niger state, Kusotachi experimental site to study the influence of planting method, weed management and timing application on growth and yield on rice. The experiment was a 2 x 6 x 2 factorial combination of two planting methods (pregerminated seeds and transplanting), six methods of weed control (Weedy check, Hoe weeding at 3 and 6 WAS, cyhalofop-butyl + MCPA, quinclorac + pyrazosulfuron-ethyl, MCPA 2 chloro 4 diphenoic acid, pretilachlor + pyribenzoxim) and two timing (Lafia and Badeggi) laid out in a Randomized Complete Block Design (RCBD) with three replications. Planting method was assigned to main plot, location was allocated to the sub plot and weed management was assigned to the sub-sub plot. The results obtained in both locations showed that, the plots with early and late application of MCPA consistently produced higher growth, yield and yield attributes of rice. The number of tillers per plant have the highest record in Lafia location while Badeggi location, recorded the tallest plants, and highest grain yield. The use of transplanting method recorded the optimum growth, yield and yield attributes of rice. Applications of early and late MCPA herbicide recorded increased growth, yield and yield attributes of rice. Therefore, it is recommended that farmers should adopt the integration of transplanting method of planting rice with early and late applications of MCPA in both locations for improved growth; yield and yield of rice.

INTRODUCTION
Rice (*Oryza sativa* L.) is a primary food crop cultivated widely over 161 million hectares in more than 100 countries across the globe (FAOSTAT, 2020). Globally, rice ranks third after wheat and maize in terms of production (Ejebe, 2013). It is cultivated on almost 11 % of the earth's cultivated land area and a wide number of ecosystems (Oluwaseyi *et al.*, 2016). China and India share 28 % and 22 % respectively of the total global rice production.

Rice constitutes major staple foods in many parts of the world. It supply more of carbohydrates, proteins, fats and also minerals vital needed for survival and healthy life (Ejebe, 2013). Rice supplies about 21 % of the total calories needed per day in human and it is a source of income to more than 100 million household around the world. it stands out as the major food crop for about a half of human race and consumption of rice its growing faster than that of any other staple in Africa and the world at large, simply because it has become a convenient food for the growing world population (Oluwaseyi *et al.*, 2016). All over the world, 26 % and 50 % increase is demanded in rice production to meet the needs of growing human population by 2035 and 2050 respectively (Rao *et al.*, 2017).

In Nigeria, the demand for rice assumed a regular increase for the past decades compared to sorghum and millet which fluctuate annually. Rice demand annually in Nigeria was estimated to about 5 million metric tons while local production around 2.21 million metric tons and about 2.79 million metric tons imported to bridge the gaps (NRDS, 2009). Weed being one of major pests in agriculture, having ability to compete with crops for nutrients through rapid growth and development.

In paddy field, weeds available nutrients uptake, compete with rice plants for water, light and space. Under adverse conditions, weeds negatively affect leaf architecture, plant developmental pattern, plant growth cycle, tillering ability, as well as yield and yield attributes of rice (Materu *et al.*, 2018). Transplanting is the most common method of planting rice, while dibbling and broadcasting are reported to be picking-up gradually (Gill *et al*., 2014). Akhgari *et al*. (2011) defined dibbling (direct seeding) of rice as the process of establishing a rice crop from seeds sown in the field rather than by transplanting rice seedlings from the nursery, it assist rice farmers to have a reduced production cost. Poor weed management also responsible for reduction in rice yield depending on weed type and their infestation (Neog *et al.,* 2015). Good weed management program is essential throughout the growing period of crops to overcome various types of weeds challenges. Manual control of weeds is not a quick method thus, requires lot of time and labour. Herbicides offer easy, economical and quick control of weeds if applied in proper dose and at proper stage of crop growth (Bhullar *et al.,* 2018). Among all measures taking in rice weed control, chemical weed control is commonly used to overcome weeds infestation and it is reliable, easy, quick, time saving, and cost effective.

There is no or little attention given by the rice growers in Nigeria on the use of metsulforun methyl, cyhalofop-butyl + MCPA, quinclorac pyrazosulfuron-ethyl, MCPA 2 chloro 4 diphenoic acid, pretilachlor + pyribenzoxim herbicides in controlling of weed in rice production due to paucity of information about the herbicides. However, this study is aiming at evaluating the effects of these herbicides application under various timing (early and late) and planting methods (pre-germinated seed and transplanting) on rice production. The objective of this study therefore is to determine the effect of location, planting methods and weed management on weed control, growth and yield of lowland rice.

MATERIALS AND METHODS

The field experiment was conducted at two locations during 2023 cropping seasons at the Teaching and Research Farm (Latitude 08.33^{0}N, Longitude 08.33^{0}E) of the Faculty of Agriculture, Shabu-Lafia Campus, Nasarawa State University Keffi, Nasarawa State, Jayeoba, 2013. And at National Cereals Research Institute (NCRI) Baddeji, Niger State at experimental site Kusotachi latitude 9°3'24.58"N, Longitude 6°8'36.31"E) Ojohomon *et al*., 2006.

The experiment is a 2 x 6 x 2 factorial combination of two planting methods (pregerminated seeds and transplanting), six methods of weed control (Weedy check, Hoe weeding at 3 and 6 WAS, cyhalofop-butyl + MCPA, quinclorac + pyrazosulfuron-ethyl, MCPA 2 chloro 4 diphenoic acid, pretilachlor + pyribenzoxim) and two location (Lafia and Badeggi) arranged in a randomized complete block design (RCBD) replicated three times. The gross plot size was 3 m x 4 m (12 m^2) while the net plot size was 1.5 m x 4m (6 m^2).

The field was cleared using a land preparation herbicide (Glyphosate a.i 360g/L) at 3 L/ha. The soil was ploughed and the site was marked into plots and replications. One meter unplanted boarder were maintained between plots, while 0.5 m unplanted boarder was maintained between each replication.The nursery was prepared in dry soil conditions on 3 by 4 m wide seed bed, was filled with top most soil to a height of 10 cm level. A layer of half burned paddy husk was distributed on the nursery bed to facilitate uprooting. 80 kg/ha of seed was used for the sowing covered with mulch, watering the beds at regular basis (morning and evening). Transplanting of vigorous healthy seedlings where done after 14-21days of germination. Five pre-germinated seeds where sown (direct seeding) and thinned to two plants per stand. For transplanting method, 14-21 days old seedlings wastransplanted from nursery bed to permanent field. One seedling per hole at a space of 20 cm by 20cm between and within the plant where maintained. Same plant spacing for transplanting was maintained for pre-germinated seed planting methods. Seed rate of 80 kg/ha where used for pre-germinated seeds while 40 kg/ha for transplanting. Fertilizer application wasdone using side placement in all the plots at the rate of 46 kg P_2O_5/ha and 64 kg N /ha. Phosphorus in the form of single super phosphate (SSP) was applied at the time of sowing and transplanting. Whereas, N in the form of UREA was applied in three splits (one third during sowing and transplanting and the remaining two third was apply in two splits at 4 and 8 WAS

The data collected included plant height tip at 4, 6, 8, 10 and 12 WAS, numbers of tillers from the tagged plants was counted and the mean recorded at 4, 6, 8, 10 and 12 WAS. The five randomly selected tagged plants from each plot where used for periodic observation during the crop growth periods at 4, 6, 8, 10 and 12 WAS. The net plot where harvested manually, grain collected, dried to 13.5% moisture content, and weight recorded. This was determined by weighing grains from the net plot, divided by net area and multiply by 10,000.

$$\text{Grain yield} = \frac{\text{Seed yield per net plot}}{\text{Net plot area}} \times 10{,}000$$

The data collected where subjected to analysis of variances (ANOVA) using SAS statistical software (version 2020) while Least Significant Difference (LSD) was used to separate treatment means at 5 % level of probability.

RESULTS AND DISCUSSION

The plant height differed significantly at 4, 6, 8, 10 and 12 weeks after sowing (WAS) for rice with respect to location, planting method and weed management as shown in (Table 1) below. Generally, Badeggi location consistently produced the tallest plants than Lafia location which consistently recorded the shortest plants throughout the sampling periods in this study.

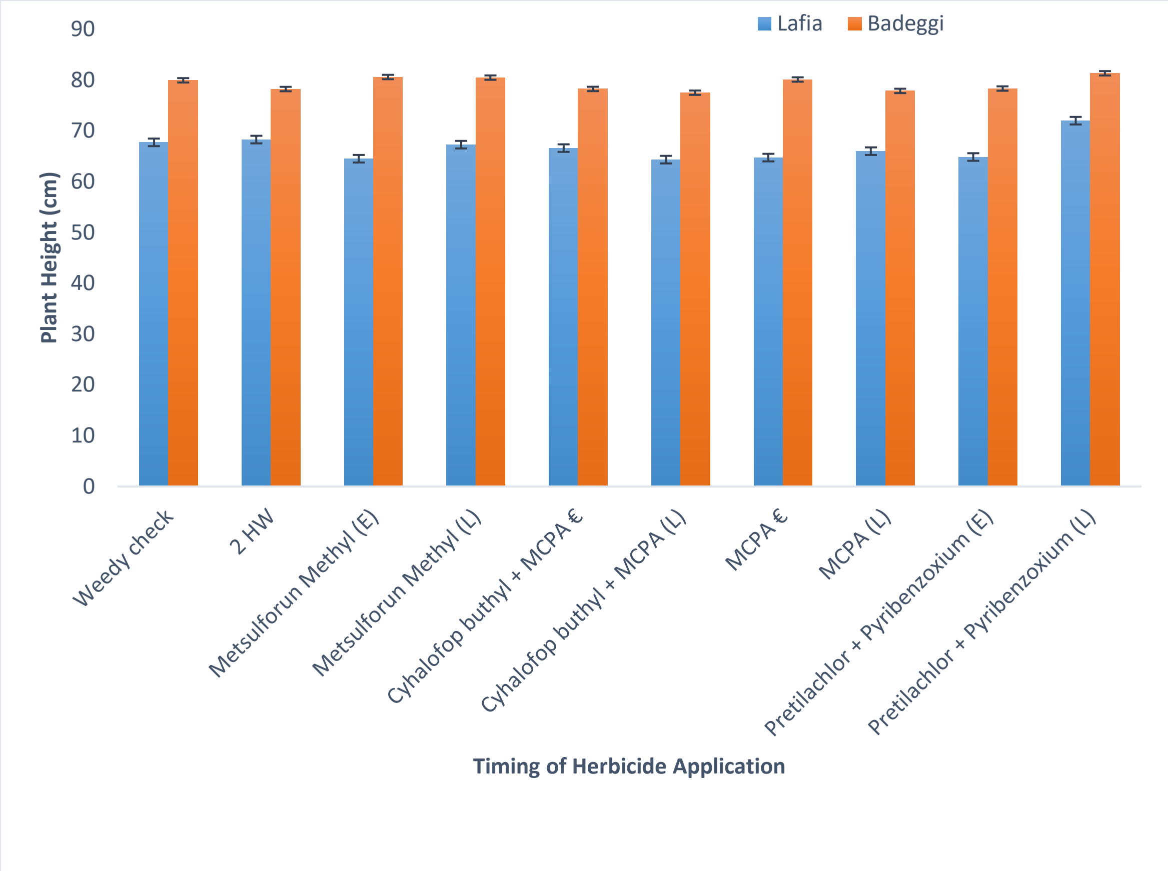
Planting method had a significant effect on plant height at 10 and 12 WAS in this study. The use of Transplanting consistently produced significantly tallest plants than the Dribbling method which consistently produced the shortest plants.

Weed management had a significant effect on plant height of rice throughout the sampling periods of the study. The weedy check, early and late applications of Cyhalofop + MCPA produced statistically similar tallest plants than the other weed controls which recorded similar shortest plants at 4 WAS. At 6 WAS, early application of Metsulforun methyl, produced significantly taller plants which was not statistically different from weedy check, early application of Cyhalofop + MCPA and early application of Pretilachlor + Pyribenzoxium compared with late application of MCPA which recorded the shortest plants. At 8 WAS, weedy check recorded the tallest plants statistically similar with 2 HW at (3 + 6 WAS), early and late applications of Metsulforun methyl, early and late applications of Cyhalofop butyl + MCPA and early application of Pretilachlor + Pyribenzoxium while late application of Pretilachlor + Pyribenzoxium recorded the shortest plants. At 10 WAS, the use of 2 HW at (3 + 6 WAS), early applications of Metsulforun methyl and late application of Pretilachlor + Pyribenzoxium produced significantly similar tallest plants than all the other weed controls compared with early and late applications of MCPA which recorded statistically similar shortest plants. At 12 WAS, late application of Pretilachlor + Pyribenzoxium produced significantly taller plants than all the other weed controls compared with late applications of Cyhalofop butyl + MCPA which produced the shortest plants.

Table 1: Effect of location, planting methods and weed control on plant height at 4 - 12 WAS of rice

	Plant height (cm)				
Treatment	4 WAS	6 WAS	8 WAS	10 WAS	12 WAS
Location (L)					
Lafia	21.92a	28.70b	32.54b	49.92b	66.34b
Badeggi	37.76a	54.91a	59.35a	69.81a	79.48a
LSD (0.05)	0.578	1.954	3.071	0.883	1.304
Planting method (PM)					
Dibbling	29.78a	41.69a	46.28a	59.52b	72.56b
Transplanting	29.89a	41.93a	45.61a	60.21a	73.29a
LSD (0.05)	0.473	0.274	2.159	0.382	0.232
Weed management (WM)					
Weedy check	30.27a	42.87ab	47.55a	59.55bc	73.86b
2 HW (3 + 6 WAS)	29.20b	42.31bc	46.86ab	61.49a	73.28bc
Metsulforun Methyl (E)	29.19b	43.34a	47.28ab	61.33a	72.58de
Metsulforun Methyl (L)	29.64b	41.54de	46.56ab	59.41c	73.90b
Cyhalofop buthyl + MCPA (E)	30.31a	42.67ab	47.17ab	58.60d	72.44e
Cyhalofop buthyl + MCPA (L)	30.46a	40.30fg	47.03ab	59.68bc	70.94g
MCPA (E)	29.58b	40.94ef	45.60abc	57.48e	72.44e
MCPA (L)	29.28b	39.98g	43.68bc	57.22e	71.95ef
Pretilachlor + Pyribenzoxium (E)	29.55b	42.63ab	45.74abc	60.24b	71.61f
Pretilachlor + Pyribenzoxium (L)	29.28b	41.80cd	42.02c	61.98a	76.68a
LSD (0.05)	0.585	0.740	3.83	0.706	0.654
Interaction					
L × PM	NS	NS	NS	NS	NS
L × WM	NS	NS	NS	NS	NS
PM × WM	NS	NS	NS	NS	*
L × PM × WM	NS	NS	NS	NS	NS

Figure 1: Below show the interaction between location, planting method and weed control on plant height at 12 WAS were significant. The combination of Badeggi location, transplanting method and early application of MCPA significantly produced the tallest plants than all the other combinations compared with the combination of Lafia location, dibbling method and late application of Metsulforun methyl recorded the shortest plants.



The effect of location, planting method and weed control on number of tillers per plant of rice at 6 - 12 WAS is shown in Table 2 below. Location affected number of tillers significantly, such that, Lafia location consistently produced significantly highest number of tillers than Badeggi location which consistently recorded the lowest number of tillers per plant.

Number of tillers per plant was significantly different among the planting methods at 10 and 12 WAS only in this study. The use of Transplanting method produced significantly highest number of tillers per plant than dibbling method which produced the lowest number of tillers per plant.

Weed management had a significant effect on number of tillers per plant at 6 - 12 WAS in this study. At 6 WAS, late application of MCPA significantly produced the highest number of tillers per plant than all the other weed controls compared with late application of Pretilachlor + Pyribenzoxium which produced the lowest number of tillers per plant. At 8 - 12 WAS, early application of MCPA consistently recorded the highest number of tillers per plant than all the other weed controls compared with the weedy check which consistently recorded the lowest number of tillers per plant which was statistically not different with 2 HW at (3 + 6) and early application of Cyhalofop butyl + MCPA at 10 WAS.

The effect of location, planting method and weed management on grain yield of rice at is presented in Table 2. Location differed significantly on grain yield, such that, Badeggi location produced significantly highest grain yield than Lafia location which had the lowest grain yield. Planting method had a significant effect on grain yield of rice. The use of transplanting method significantly recorded the highest grain yield than dibbling method which gave the lowest grain yield in this study. Weed management also affected grain yield of rice significantly, such that, the application of early and late MCPA gave statistically similar highest grain yield than all the other weed managements compared with the weed check which recorded the lowest grain yield in this study.

Table 2: Effect of location, planting methods and weed management on number of tillers

	Number of tillers			
Treatment	5 WAS	6 WAS	7 WAS	Grain yield kg/ha
Location (L)				
Lafia	4.31a	10.42a	13.09a	4164.6b
Badeggi	4.01b	6.28b	10.18b	4313.8a
LSD (0.05)	0.11	1.51	0.68	124.34
Planting method (PM)				

Dibbling	4.27a	8.26a	10.97b	3891.5b
Transplanting	4.04a	8.43a	12.30a	4586.8a
LSD (0.05)	0.25	0.18	0.28	22.08
Weed management (WC)				
Weedy check	4.15b-e	8.10d	10.74ef	1533.7i
2 HW (3 + 6 WAS)	3.91ef	8.13cd	10.82ef	3519.6h
Metsulforun Methyl (E)	4.48ab	8.18cd	11.62cd	5457.9b
Metsulforun Methyl (L)	4.23b-e	8.28bcd	11.70c	5268.7c
Cyhalofop buthyl + MCPA (E)	4.10cde	8.21bcd	10.97ef	4519.6e
Cyhalofop buthyl + MCPA (L)	4.28a-d	8.66ab	11.12def	4615.0d
MCPA (E)	4.12cde	9.02a	14.12a	6089.6a
MCPA (L)	4.61a	8.58abc	13.18b	6056.3a
Pretilachlor + Pyribenzoxium (E)	3.98def	8.19bcd	11.75c	3868.8f
Pretilachlor + Pyribenzoxium (E)	3.67f	8.05d	11.69c	4577.1d
LSD (0.05)	0.34	0.47	0.57	54.47
Interaction				
L × PM	NS	NS	NS	NS
L × WC	NS	NS	NS	NS
PM × WC	NS	NS	NS	NS
L × PM × WC	NS	NS	NS	NS

DISCUSSION

The tallest plants and highest grain yield recorded at Badeggi location may be due to the productivity of soil of the location and the suitability of the weather conditions of the study area which supported the utilization of growth factors (water, nutrients and solar radiation) and hence the production of optimum growth, yield and yield attributes of rice in this study.

The tallest plants, highest number of tillers and grain yield produced by transplanting method could be attributed to the specific distance between the plants and the competition between plants were minimum and deep penetration of roots resulting in efficient nutrient uptake and good plant growth. Also, transplanted rice seedlings have a 'head start' over germinating weed seedlings, leading to competitive control of weeds. This result is in line with the work of (Yakubu., 2013) who reported maximum plant height in transplanted rice due to the reason that plants were at specific distance and the competition between the plants were minimum and deep penetration of roots resulting in efficient nutrient uptake and good plant growth.

The shortest plants, lowest number of tillers per plant and grain yield produced by the weedy check as compared with plots with weed management may be due to the effectiveness of the herbicide which lead to the inhibition of weed seeds in the soil and killing of the weed seedlings already emerged in rice fields in this study. Anwar *et al*. (2013) reported that among the herbicides, Propanil/Thiobencarb and Cyhalofop butyl + Bensulfuron caused no visible injury to rice plant, while Pretilachlor/Safener, Bispyribac Sodium, and Bentazon/MCPA showed slight phytotoxicity to rice. Pytotoxicity of Pretilachlor/Safener was characterized by minor reduction in plant height and slight leaf chlorosis as observed at 7DAA. Khan *et al*. (2014) reported that the best performance of Triasulfuron herbicides can be attributed to the best control of weeds which reduced weed competition and enable increased flow of nutrients towards the grains and ultimately increased the grain yield.

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EVALUATION OF SOME SELECTED HEAVY METALS IN UNDERGROUND WATER CAUSED BY MECHANIC ACTIVITIES IN MAKURDI METROPOLIS

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ABSTRACT
Well Water samples were collected from three sampling areas at different sampling points at the mechanic villages at Apir, North Bank and New Garage in Makurdi metropolis for heavy metals specifically Iron (Fe), Zinc (Zn), Copper (Cu), Silver (Ag), Manganese (Mn), Lead (Pb), Chromium (Cr), Cadmium (Cd), Arsenic (As) and Mercury (Hg). The samples were analyzed using pH meter and Atomic Absorption Spectrophotometer (AAS). The data were compared with the World Health Organization (WHO) standards. The results showed that the concentration in mg/L of all the heavy metals were found within the maximum allowable limits of WHO, with the exception of Cadmium at all the locations where they were found to have concentrations above the WHO's standards in most of the wells investigated. The results also showed that the mechanic activities at these three (3) areas are responsible for the concentrations of these heavy metals. Therefore, the water in the areas studied especially at the Apir Mechanic Village is not safe for both human purposes.
***Keywords:** Heavy metals, Underground water, Pollution, Mechanic activities, Health.*

INTRODUCTION
Water is ranked among the most remarkable compounds owing to its unique physical and chemical properties and importance for biological activities of living organisms. Water, a universal solvent which makes up about 70% of man's body is one of the most commonly available natural resources of man. (Talabi *et al*., 2020). For water with its innumerable physical, chemical and biological properties to meet the demands and vital functions for human, plants and animals, has to satisfy a number of quality requirements. A good water quality, therefore, is one that meets the WHO's set standards and standards set by other water regulatory bodies. The quality of water varies greatly from diverse sources which include surface, rain and underground. The quality of these water bodies vary depending on the location and environmental factors (Adetunde *et al*, 2011). Heavy metals on the other hand can be defined as "metals with densities that are five times heavier than water and are formed naturally from the terrestrial environments, and are found in rocks, plants, soils and sediments" (Talabi *et al.,* 2020;,Orobator et al.,2020).WHO (2011) define heavy metals as metallic elements with an atomic weight > 40. Heavy metals are non-degradable and indestructible hence their presence in the earth's crust poses a consistent environmental contamination. Ukah *et al.,* (2019) opined that their excessive accumulation in the body is a big threat to human health. Pollution caused by heavy metals has been considered as a serious environmental health problem as a result of its toxicity even at low concentration, persistence, and bioaccumulation ability (Olagunju *et al*., 2020).. Once the water bodies and the environment are contaminated with excess heavy metals, health risks and hazards are inevitable (Ukah *et al.,* 2019). To avoid diseases caused by heavy metals to the existing pandemic rampaging Nigeria and the world at large, it is important to check the status of water (underground water in this case) intermittently, for monitoring and prevention of further outbreak and health hazards. This research works was aimed at evaluating heavy metals pollution in well water caused by mechanic activities and its consequent implication on health of makurdi dwellers and compare the results with WHO set standards for heavy metals.

METHODOLOGY
Materials
Soil samples
HNO3
HCl
Weighing balance
Atomic Absorption Spectrophotometer

Kjeldal apparatus
Metals e.g. Fe, Zn, Cu, Hg, Ag, Mn, Pb, Cr, Cd, and As.

METHODS

The research began with a preliminary investigation of Makurdi metropolis in order to understand the area under study and the mechanic activities taking place there. The study area was then divided into three areas namely: Apir, North Bank, and the New-garage mechanic areas. Then, a survey of water samples from dug wells were carried out around the three mechanic villages. At the Apir mechanic area, five (5) dug wells were discovered within the distance of 120 m. At the North Bank area, five (5) wells were found at the same approximate distance of 30m apart. At the New garage, three wells were found within the distance of 60m. A total of 13 water samples were collected in a labeled plastic swam water bottles, one from each sampling area. The depth of the wells, colour of water and pH of the waters were all taken..

Laboratory Analysis of the Heavy Metals

Digestion of the samples was carried out using Kjeldahl apparatus at temperature of 100°C and a mixture of HNO_3 and HCl in a ratio of 3:1 added to the beaker containing 0.5g of the samples. The concentrations of the heavy metals from each of the filtered samples were determined using Atomic Absorption Spectrophotometer (AAS).

Data Analysis

The data obtained were compared to the World Health Organization (WHO) set Standards.

RESULTS AND DISCUSSION

The results of the analysis carried out are represented in Table 1, 2 and 3 as shown below:

Table 1: Results showing the concentrations of heavy metals at Apir

Distance	*Fe*	*Zn*	*Pb*	*Cu*	*Mn*	*Cd*	*Cr*	*As*	*Hg*	*Ag*	pH
30m	0.21	2.684	0.018	0.370	0.031	0.0030	0.0030	0.032	0.0006	0.0007	6.5
60m	0.16	2.133	0.015	0.289	0.024	0.0027	0.0028	0.026	0.0004	0.0006	6.8
90m	0.14	1.600	0.008	0.430	0.011	0.0025	0.0024	0.017	0.0004	0.0003	7.4
120m	0.12	0.950	0.014	0.500	0.04	0.0021	0.0013	0.013	0.0003	0.0002	8.0

***Table 2:* Results showing the concentrations of heavy metals at Northbank**

Distance	Fe	Zn	Pb	Cu	Mn	Cd	Cr	As	Hg	Ag	pH
30	*0.27*	*1.350*	*0.015*	*0.436*	*0.040*	*0.0028*	*0.0043*	*0.017*	*0.00040*	*0.0005*	6.7
60m	*0.18*	*1.270*	*0.013*	*0.350*	*0.033*	*0.0015*	*0.0037*	*0.014*	*0.00019*	*0.0004*	6.8
90m	*0.15*	*1.119*	*0.010*	*0.311*	*0.025*	*0.0011*	*0.0030*	*0.012*	*0.00025*	*0.0004*	7.0
120m	*0.12*	*1.005*	*0.006*	*0.260*	*0.016*	*0.009*	*0.0023*	*0.012*	*0.00015*	*0.0002*	7.2

***Table 3:* Results showing the concentrations of heavy metals at New garage.**

Distance	*Fe*	*Zn*	*Pb*	*Cu*	*Mn*	*Cd*	*Cr*	*As*	*Hg*	*Ag*	*pH*
0m	*0.150*	*1.350*	*0.0012*	*0.363*	*0.045*	*0.0015*	*0.0016*	*0.022*	*0.00021*	*0.00017*	*6.5*
30m	*0.80*	*0.850*	*0.010*	*0.270*	*0.035*	*0.0011*	*0.0021*	*0.015*	*0.00017*	*0.00014*	*6.8*
60m	*0.065*	*0.750*	*0.007*	*0.185*	*0.018*	*0.0007*	*0.0018*	*0.013*	*0.00010*	*0.00010*	*7.0*

Table 4: WHO Standards for drinking water Quality;

Parameters	*As*	*Cd*	*Cr*	*Cu*	*Fe*	*Pb*	*Mn*	*Hg*	*Ag*	*Zn*	*pH*
Maximum Allowable	*0.1*	*0.005*	*0.05*	*2.0*	*0.3*	*0.01*	*0.4*	*0.006*	*0.05*	*3.0*	*6.5-9.2*

Source: Beyene and Berhe, (2015)

DISCUSSION

The concentration of the chemical properties of underground water for 11 samples (4 at Apir, 4 at North Bank and 3 at New garage areas of Makurdi metropolis) are represented in Table 1, 2 and 3 as shown above. Table 4 represents the World Health Organization (WHO) maximum allowable limit recommended for heavy metals in water sources, which is used as a tool for comparing the data obtained in this work. The pH of all the water samples analyzed were found to be in a range of 6.5-8.0. These values are all within the WHO recommended standard of 6.5-8.5 (WHO, 2015). It was observed that, the concentrations of the heavy metals with exception of Pb and Cu at Apir and Cr at New garage were found to decrease steadily with increasing distance away from the mechanic sites. However, the concentrations with exception of cadmium were all within the maximum allowable limits of WHO (WHO, 2015). Zinc recorded the highest concentrations at all the three places though within the maximum allowable limits. At the Apir mechanic village, the concentration of Zinc was 2.684mg/L, which was the highest of all. The concentrations of Zn at both Apir and North Bank decreases with increase in distance away from the mechanic villages. However, they were all within the maximum limits of 3.0 standards set by WHO (WHO, 2015).

CONCLUSION

From the results of the analysis carried out, it is observed that, of all the concentrations of the heavy metals studied at the three areas, the Apir mechanic village recorded the highest concentration values of cadmium, which is above the maximum allowable limit set up by the World Health Organization (WHO) in drinking water. This may be attributed to the high or large scale mechanic activities taken place at this area particularly electroplating where they are used as solders for joining metals. With exception of cadmium, all the heavy metals investigated have concentrations within the maximum permissible limit set up by WHO. Moreover, the concentrations of all the heavy metals analyzed, cadmium inclusive decreased with increase distance as one moves away from the mechanic sites. As a result of this, we can generally conclude that the mechanics activities at these places are largely responsible for the concentrations of these heavy metals in ground water. With cadmium and zinc showing higher concentrations, at these three places it can be inferred that the waters in these places are not safe for drinking and even for agricultural purposes.

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GROWTH AND YIELD OF AMARANTH (*AMARANTHUS CRUENTUS*) AS AFFECTED BY DIFFERENT SOURCES OF IRRIGATION WATER IN IBADAN, SOUTH-WESTERN NIGERIA

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ABSTRACT
The most limiting factor in vegetable production is water, the quality and amount of water play an important role in the growth and yield of vegetables. This study was carried out with the aim to investigate the effects of different irrigation water sources on the growth and yield of Amaranthus cruentus. The experiment was set up in a randomized complete block design, carried out in four locations in Ibadan which lies in the forest agro-ecological zone of Nigeria. Water used for irrigation were borehole water which serve as the control and river water at the different locations. Ten plants were randomly selected from each plot and tagged for data collection on plant height (cm), stem diameter (cm), number of leaves, leaf area (cm^2) and leaf yield (kg/ha). Data collected were subjected to analysis of variance (ANOVA) and significant means were separated using the least significant difference at a 5% probability level. Plant height of amaranth at early stage (3 and 4 weeks after planting) were not significantly different from one another at the various locations but as growth advanced to 5 WAP, amaranth planted at NIHORT Upland (42.56 cm) was significantly taller than those cultivated in Akilapa (26.82 cm) and NIHORT Lowland (30.57 cm) but not significantly different from those planted at Babalegba (36.36 cm). Leaf yield of A. cruentus grown at different locations with different sources of irrigation water varied significantly across the four locations, amaranth cultivated in upland of NIHORT had significantly higher leaf yield (22.3t/ha), followed by leaf yield of amaranth grown at Babalegba which had 17t/ha while those planted at lowland of NIHORT and Akilapa produced leaf yield of 9.1t/ha and 6.1t/ha respectively. In conclusion, growth and yield of A. cruentus varied with irrigation water sources.

Keywords: *Irrigation water, Amaranthus cruentus, water quality, vegetable, growth and yield,*

INTRODUCTION
Amaranth is a leafy vegetable that is commonly grown in the tropics and is one of the most significant leafy vegetables in Africa and Asia's lowlands (Andreas *et al.,* 2011). It is a nutritious vegetable rich in calcium, iron, protein, vitamins A, C, and K, riboflavin (B2), niacin (B3), vitamin B6, and folate (B9). Amaranth is a fast-growing annual plant that can be easily grown in home gardens and on a commercial scale. *Amaranthus cruentus* belongs to the family Amaranthaceae, it contains a lot of genetic variation in terms of plant form (erect to prostrate), plant height, number of inflorescences (one to many), seed color, protein content, seed yield, pest and disease resistance, and adaptation to soil type, pH, climate, rainfall, and day length (Kulakow, 1990). Amaranth is a plant that thrives in arid conditions. Amaranth seeds sprout best in soil temperatures between 18^{0}C and 25^{0}C, and they thrive best at air temperatures above 25^{0}C. At temperatures below 18^{0}C, the growth stops. Amaranthus may grow in a variety of soil types and moisture levels, it has been observed to thrive in loamy, sandy-loam, or silty-loamy soils with good water holding capacity and a pH range of 4.5 to 8.0 (National Research Council, 1984; Palada and Chang, 2003).

Various parts of the plant have been utilized for a variety of reasons, including food, feed, ornamentals, sacraments and traditional medical treatments. The commercialization of indigenous green-leaf vegetables supports the local economy in addition to playing an essential role in African diets (Lenne and Ward, 2010) and it is an integral component of traditional African medicine (Padulosi *et al.,* 2013). Amaranthus leaves have a high nutrient value, ranging from 4 to 6 g of protein, 0.2 to 0.6 g of fat, and 4 to 7 g of carbohydrates per 100 g of fresh leaves (Uusikua *et al.,* 2010) and are known to be high in micronutrients and vitamins, particularly chlorine, copper, iron, manganese, sodium, vitamin A, vitamin C, and vitamin B-12 (Mnkeni, 2005). Amaranthus seeds have a protein content of 12.5 to 17.6% (Teutonico and Knorr, 1985) with significantly higher levels of lysine (0.73 to 0.84 percent of total protein content) and sulfur-containing amino acids (methionine and cysteine) than other cereal grains (Railey, 1993; Lehmann, 1996; Petr *et al.,* 2003), and thus have the potential to improve the world food situation as an alternative.

Water is a major limiting factor in agricultural productivity, and crop water requirements must be met in order for the crop to grow and yield optimally. According to Musa (2001), the overall unreliability and unpredictability in the temporal and spatial distribution, as well as lack of rainfall, frequent droughts, and rapid population expansion, have all conspired to make irrigation an important part of Nigeria's food security strategy. Most Leafy vegetables benefit from frequent irrigation throughout the season. In Nigeria, the production of *Amaranthus cruentus* has increased through irrigation farming system due to the increase in population and demand for the crop. The most limiting factor in vegetable production is water; the quality and amount of water play an important role in the growth and yield of vegetables. Increase in demand for vegetables keeps rising as a result of an increase in population which cannot be efficiently addressed by rain-fed agriculture. The irrigation farming system has gained attention in Nigeria in the production of vegetables but the quality of water used for irrigation is not considered by local farmers. Most sources of water used for irrigation are polluted which are detrimental to the soil, plant, and human. The objective of this study was therefore to investigate the effects of different sources of irrigation water on growth and yield of *Amaranthus cruentus*.

MATERIALS AND METHOD

The experiments were carried out in four different locations within Ibadan metropolis:

1. Babalegba" along Sanngo - Eleyele Road (Long. 7.522^{0}N and Lat. 3.316^{0}E),
2. Akilapa along All saint's College Road (Long. 7.797^{0}N and Lat. 3.771^{0}E),
3. NIHORT Lowland (Long. 7.443^{0}N and Lat. 3.037^{0}E) and
4. NIHORT Upland (Long. 7.639^{0}N and Lat. 3.365^{0}E).

The experiment was conducted at Vegetable Research Farm of NIHORT, Ibadan, Oyo state and other locations were around NIHORT in dry season of 2022. The sites lies within the Rain-forest agro-ecological zone of Nigeria. The soil is dominated by Alfisols, the monthly rainfall distribution pattern for Ibadan is bimodal with peaks in June and September. Annual rainfall ranges from 1250 mm and 1500 mm spanning eight months (March to October) with dry spell in August.

The study was a one factor experiment laid out in a randomized completely block design (RCBD) in three replications. The treatments consist of four locations which served as different sources of irrigation water, flowing river close to the experimental sites was used to irrigate the field at Akilapa, Babalegba and NIHORT lowland while borehole water was used to irrigate experimental site at NIHORT upland. Seeds of *Amaranths cruentus* obtained from NIHORT were drilled in rows of 40 cm apart on seed bed of 3 m × 3 m in each location Water from each location was used to irrigate the plants daily at the rate of 8 l/m^2 (Grubben, 2004) Soil samples were collected from each sites using a soil auger at a depth of 0 - 15 cm. The soil was air-dried and sieved using a 2 mm sieve. The sieved soil samples, water used for irrigation at each site and plant samples after harvesting were taken to the laboratory for analysis to determine both their physical and chemical properties. Ten plants were randomly selected from each plot and tagged for data collection on growth and yield of the crop commencing from three weeks after planting weekly intervals for 3 weeks. Data collected on plant height (cm), stem diameter (cm), number of leaves, petiole length (cm), leaf area (cm^2) which was determined by measuring the length and width of the leaf and was calculated using 0.5 (Length x width) Pearcy *et al.* (1989) and leaf yield (kg/ha) were subjected to analysis of variance (ANOVA) using SAS software (1990), and significant means were separated using the least significant difference at a 5% probability level.

RESULT AND DISCUSSION

The soil textural class, physical and chemical properties of the soil of each location where the experiment was carried out as shown in Table 1 revealed the textural class of the soil in the different locations to be loamy soil. Result of heavy metal concentration present in water used for irrigating the amaranth cultivated in the four locations. The heavy metals in the water used for irrigation in the different locations were within the permissible level as recommended by WHO (1996) except for that of Babalegba which was high in the lead (Pb) (Table 2). Fig. 1 showed that plant height of amaranth at 3 and 4 weeks after planting (WAP) were not significantly different from one another at the various locations but at 5 WAP, amaranth planted at NIHORT Upland (42.56 cm) was significantly taller than those cultivated in Akilapa (26.82 cm) and NIHORT Lowland (30.57 cm) but not significantly different from those planted at Babalegba (36.36 cm). In line with the findings of this study, researchers have reported that plant height of amaranth is not significantly affected by the location of cultivation or the type of irrigation water used, especially at early stages of growth (Muhammad *et al.*, 2017; Adekiya *et al.*, 2020). However, at 5 WAP, amaranth cultivated in NIHORT Upland was significantly taller than those cultivated in Akilapa and NIHORT Lowland, indicating that growth of amaranth may be influenced by the location and type of irrigation water used at later stages of growth. This corroborates the result of Adekiya *et al.* (2020) who observed a significant effect of irrigation water on height of amaranth at 5 WAP.

Table 1: Pre-cropping analysis of soil

	Babalegba	NIHORT Upland	Akilapa	NIHORT Lowland
Ph	7.65	6.56	6.29	7.31
E.Cus/cm	94	40	198	43
%O.C	1.74	2.09	0.87	1.19
%N	0.19	0.23	0.1	0.13
P mg/kg	37.4	94.8	47.7	8.8
Exch Acidity	0.35	0.3	0.3	0.3
Exch H (cmol/kg)	0.35	0.3	0.3	0.3
ExchAl	0	0	0	0
Ni mg/kg	25.2	15.6	9.9	10.95
Ca cmol/kg	11.93	2.56	3.83	2.72
Mgcmol/kg	1.02	0.8	0.97	0.78
Kcmol/kg	0.09	0.14	0.08	0.1
Na cmol/kg	1.09	0.91	0.83	0.96
Mn	89	124	74	79
Fe	101	131	83	96
Cu	37.15	11.45	6	4.15
Zn	215	33.1	13.7	13.3
Pb	0	0	0	0
Cd	0	0	0	0
% Sand	79	82	80	82
% Silt	12	11	11	13
% Clay	9	7	9	5
Textural class	Loamy soil	Loamy soil	Loamy soil	Loamy soil

Table 2: Concentration of heavy metals in water used for irrigation in all the locations under study

Heavy metals	**Babalegba**	**NIHORT upland**	**Akilapa**	**NIHORT lowland**	**Safe value**
Mn (mg/L)	0.552	0.05	0.081	0	0.5
Fe (mg/L)	2.576	0	0.291	0.432	0.3
Cu (mg/L)	0.037	0.076	0.025	0.001	2
Zn (mg/L)	0.028	0.078	0.068	0.045	5
Ni (mg/L)	0.166	0	0	0.113	0.2
Pb (mg/L)	4.811	0	0	0	0.1
Cd (mg/L)	0	0	0	0	0.1

Note: Mn –Manganese, Fe – Iron, Cu – Copper, Zn – Zinc, Ni – Nickel, Pb – Lead, Cd – Cadmium
The safe value as recommended by WHO (1996)

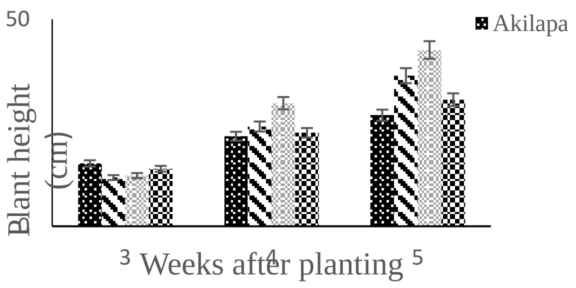

Fig. 1: Plant height (cm)

Fig. 2: Number of leaves

Number of leaves of amaranth cultivated in the four locations as influenced by different river sources of irrigation water presented in Fig. 2 showed that there was no significant difference in the number of leaves produced by amaranth cultivated in all the four locations at 3 WAP but as growth advanced to 4 WAP, number of leaves of amaranth grown in NIHORT Upland (17) was significantly higher than those cultivated in other locations. Meanwhile, amaranth grown at NIHORT lowland produced the least number of leaves (11.6) though not significantly different from that of Akilapa (11.9). At 5 WAP, amaranth grown at NIHORT upland still produced the highest number of leaves (25) but not significantly different from that of Babalegba (21.46) while Amaranth cultivated in Akilapa has the least number of leaves (13.8), which suggests that the low percentage of Organic Carbon (0.87%) and Nitrogen (0.1%) in that location might be responsible for this poor growth and development of *A. cruentus*. As reported by Qiang *et al*. (2014) that Nitrogen is one of the major elements for plants growth and metabolism.

Result of the study showed that there was significant effect of the different sources of irrigation water on the leaf area of amaranth. At 3WAP, amaranth grown in both Upland and lowland of NIHORT and Akilapa were comparable to each other in terms of leaf area (13.34 cm^2, 13.52 cm^2 and 11.16 cm^2, respectively), while amaranth cultivated in Babalegba produced the least leaf area of 8.33cm^2. The same trend was also observed at 4 WAP where no significant difference was observed in the leaf area of amaranth cultivated in both upland and lowland of NIHORT and Akilapa (30.48, 21.52 and 24.12 cm^2, respectively) with that of Babalegba having the least leaf area (16.85 cm^2). At 5 WAP, there was no significant difference in the leaf area of amaranth cultivated in NIHORT upland (31.48 cm^2), NIHORT Lowland (27.18 cm^2), and Babalegba (26.15cm^2). However, amaranth in these three locations had significantly wider leaves than those cultivated in Akilapa which had the least leaf area of 14.996 cm^2 (Fig. 3). The leaf area of *A. cruentus* cultivated in NIHORT Upland, NIHORT lowland, and Akilapa was significantly wider than that of Babalegba. This suggests that the irrigation water quality in Babalegba may not be optimal for the growth and development of *A. cruentus* which is accordance with the finding of Adekiya *et al*. (2020) that water quality can have an impact on leaf area in amaranth.

The results of stem diameter of amaranth planted in four different locations grown with different sources of irrigation water as shown in Fig. 4 revealed that significant difference existed in the stem diameter of amaranth throughout the growth stages of the amaranth. At 3 and 4 WAP, amaranth grown in upland of NIHORT had the highest stem diameter (0.76 and 0.96 cm, respectively) while no significant difference existed in the stem diameter of amaranth planted in other three locations. At 5 WAP, amaranth planted in upland of NIHORT still had the highest stem diameter (0.99 cm) but not significantly from those planted at lowland of NHORT (0.72 cm). Leaf yield of *A. cruentus* grown at different locations with different sources of irrigation water varied significantly across the four locations, amaranth cultivated in upland of NIHORT had significantly higher leaf yield (22.3t/ha), followed by leaf yield of amaranth grown at Babalegba which had 17t/ha while those planted at lowland of NIHORT and Akilapa produced leaf yield of 9.1t/ha and 6.1t/ha respectively (Fig. 5). The leaf yield of *A. cruentus* varied significantly across the four locations, these differences could be attributed to various factors such as the soil type, the quality of irrigation water, and the level of heavy metal contamination in the soil. The higher yield of *A. cruentus* in NIHORT Upland could be due to the favorable soil condition which provided the necessary nutrients for the growth and development of the plant (Olowoake and Ojo, 2014).

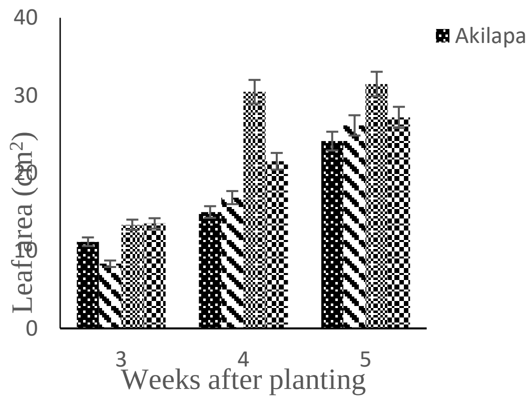

Fig. 3: Leaf area (cm^2)

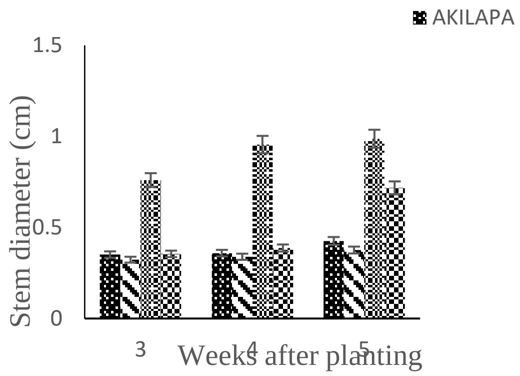

Fig. 4: stem diameter (cm)

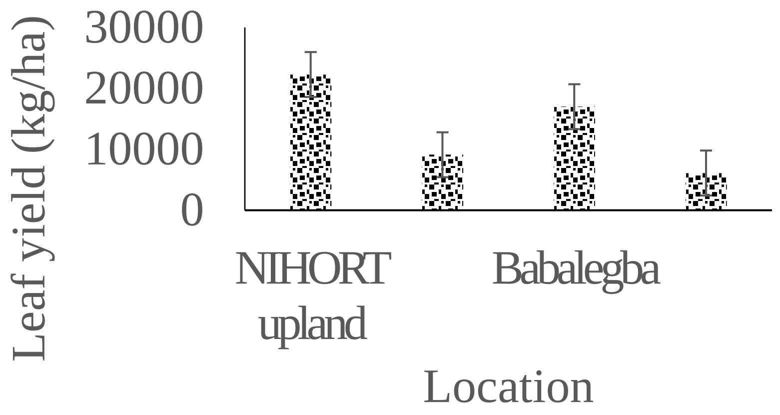

Figure 5: Yield (kg/ha) of amaranth grown in different locations with different sources of irrigation water

CONCLUSION

The study revealed that growth and yield of *Amaranthus cruentus* were significantly influenced by location and irrigation water source. Differences in soil fertility and irrigation water sources possibly enhanced growth and yield of amaranth.

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EVALUATION OF LOW-COST SEMI-AUTOTROPHIC HYDROPONIC (SAH) SUBSTITUTES FOR SWEETPOTATO PRODUCTION

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ABSTRACT
UMUSPO/3, BUTTERMILK and TIS 87/0087 Sweetpotato varieties selected from screen house of Sweetpotato in NRCRI were surfaced sterilized and planted in different substrates of Klasmann (K), Soyabean husk (S), Coco peat (C), Rice husk (R) and in selected combination. The vigour rate, survival rate and growth rate were measured as indicators to evaluate the performance of the different varieties of sweetpotato in different substrates application. The experiment was a 3 by 6 Factorial design laid out in Randomized Complete Block Design (RCBD) with 18 treatments and three replicates. The data collected from the experiment were subjected to analysis of variance (ANOVA) using the R software package. The results indicate that for all the three Sweetpotato varieties, C and combination of both K, S and C have significant effect ($p<0.05$) compared to combination of K and R, and R and S respectively on the Growth rate (UMUSPO/3-C, 3.306, combination of K, S and C, 2.861, K and R, 0.361, R and S, 0.194, BUTTERMILK- C, 2.306, combination of both K,S and C, 1.417, K and R, 0.472, R and S, 0.417 and TIS 87/0087- C, 2.778, combination of both K, S and C, 2.639, K and R, 0.67, R and S, 0.194). Similar effects were observed for the Survival rate (UMUSPO/3-C, 3.472, combination of K, S and C, 3.250, K and R, 0.444, R and S, 0.250 BUTTERMILK- C, 2.611, combination of both K,S and C, 2.444, K and R, 0.361, R and S, 0.361 and TIS 87/0087- C, 3.417, combination of both K, S and C, 3.167, K and R, 0.361, R and S, 0.167), and Vigour (UMUSPO/3-C, 3.389, combination of K, S and C, 2.639, K and R, 0.444, R and S, 0.444 BUTTERMILK- C, 2.250, combination of both K,S and C, 2.833, K and R, 0.361, R and S, 0.556 and TIS 87/0087- C, 2.861, combination of both K, S and C, 3.222, K and R, 0.472, R and S, 0.444). This suggests that Coco peat and Soyabean husk can serve as possible alternatives and supplements for Klasmann in Semi Autotrophic Hydroponic techniques (SAH) in order to save cost.
Keywords: *Sweetpotato, Klasmann, Soyabean husk, Coco peat, Rice husk, semi-autotrophic hydroponic*

INTRODUCTION
Sweetpotato (*Ipomoea batatas* Lam.) is an important tuber crop grown in over 120 countries in the world, on about 8 million hectares of land, and with a total annual production of about 92 million tons with a yield of 114 ton ha (FAO, 2018). The crop grows in a wide range of soils but prefers moderately fertile, well –drained, deep, light or medium textured soils, with pH ranging from 4.5 to 7.0 (Abidin *et al*., 2017; Makini *et al*., 2018). Sweetpotato is considered a food security crop in sub-Sahara Africa due its fast growing period with low input requirements. Most products are derived from roots, while the vegetative parts can be utilized as vegetable and feed for livestock (Lebot, 2009). Inadequate availability of quality Sweetpotato vines limits the utilization of improved and new varieties. Farmers are faced with the challenge of obtaining clean planting material and in the right quantity. Despite the many advantages, Sweetpotato is still susceptible to biotic and abiotic stresses that hinder its production. Semi-Autotrophic Hydroponics (SAH) is a technology targeted at mass propagation of virus – free plants of tissue culture. It is an easy to adapt technique suitable for commercial seed multiplication and production. It involves the use of modified soil, which holds plant roots in planting pots with little water. With this technology farmers will have easy access to new varieties once they are developed. However, the cost of SAH substrate (Klasmann) is expensive. Therefore, the objectives of our study are to identify and determine the efficacy of locally-sourced substrates as alternatives to the expensive Klassman, to develop composite formulations of the different substrates and to evaluate the locally available substrate in a 50:50 or equal combinations with Klassman.

MATERIALS AND METHODS
The experiment was carried out in semi autotrophic hydroponic (SAH) at the NRCRI Umudike on Latitude 5.5°N, 7.5°E, South-East region of Nigeria at altitude 1800m (mean sea level). Three Sweetpotato varieties namely

UMUSPO/3, BUTTERMILK and TIS 87/0087 were selected from the screenhouse of Sweetpotato in NRCRI, surfaced sterilized by washing in running, followed in Benlate liquid fungicide, 70% ethanol and finally rinsed with distilled water, and planted in a bucket containing air dried river sand with substrate which have been autoclaved at 121Psi for 30 minutes. The experiment was set in a 3 by 6 Factorial design laid out in Randomized Complete Block Design (RCBD) with 18 treatments and three replicates.
The Growth rate, Survival rate and Vigour were measured to determine the performance of the three Sweet potato varieties on different level of substrates application. Data collected from the experiment was subjected to analysis of variance (ANOVA) using the R software package.

RESULTS AND DISCUSSION

Growth rate from fig 1 revealed UMUSPO/3-C, 3.306, combination of K, S and C, 2.861, K and R, 0.361, R and S, 0.194, BUTTERMILK- C, 2.306, combination of both K,S and C, 1.417, K and R, 0.472, R and S, 0.417 and TIS 87/0087- C, 2.778, combination of both K, S and C, 2.639, K and R, 0.67, R and S, 0.194). The results showed that the effect of substrates on the growth rate of Sweetpotato has significant ($p<0.05$) difference with significant positive effect found in Coco peat and combination of both Klasmann, Coco peat and Soya bean husk while the least effect occurs for combination of both Klasmannand Rice, and Rice husk and Soya bean husk.
Similar effects were observed for the Survival rate as showed in fig 2 (UMUSPO/3-C, 3.472, combination of K, S and C, 3.250, K and R, 0.444, R and S, 0.250 BUTTERMILK- C, 2.611, combination of both K,S and C, 2.444, K and R, 0.361, R and S, 0.361 and TIS 87/0087- C, 3.417, combination of both K, S and C, 3.167, K and R, 0.361, R and S, 0.167). There was significant difference between Klasmann and other substrates on the survival rate of Sweetpotato. This suggested that Coco peat and combination of both Klasmann, Soyabean husk and Cocoa peat could be used in placed of Klasmann for survival rate.
From Fig. 3, the result of the Vigour (UMUSPO/3-C, 3.389, combination of K, S and C, 2.639, K and R, 0.444, R and S, 0.444 BUTTERMILK- C, 2.250, combination of both K,S and C, 2.833, K and R, 0.361, R and S, 0.556 and TIS 87/0087- C, 2.861, combination of both K, S and C, 3.222, K and R, 0.472, R and S, 0.444) showed that there was significant difference among the substrates. These results were similar with that obtained by Ritter *et al.* 2001 but further research should be carried out to validate these preliminary findings.

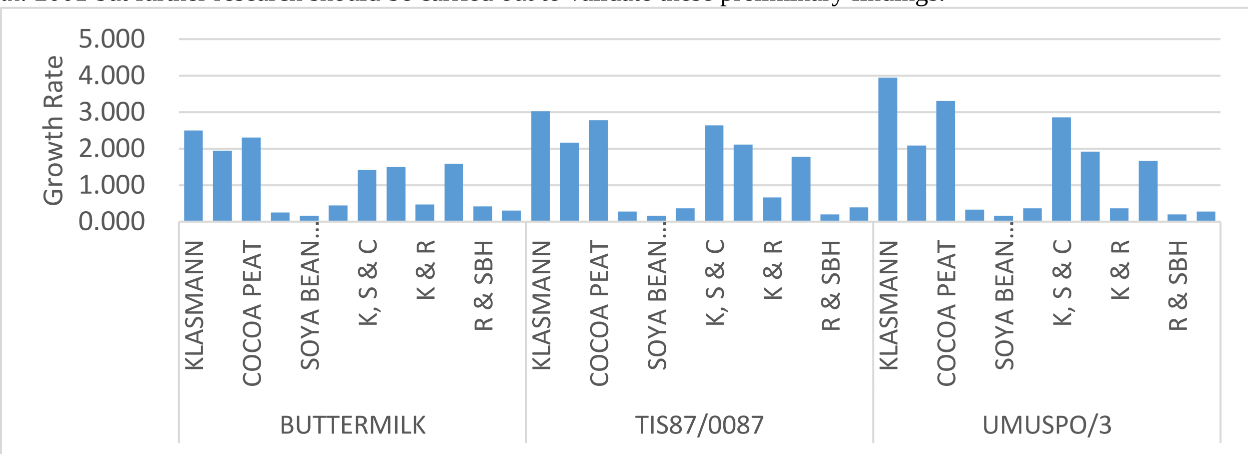

Fig 1: Effect of Substrates on Growth rate of Sweetpotato

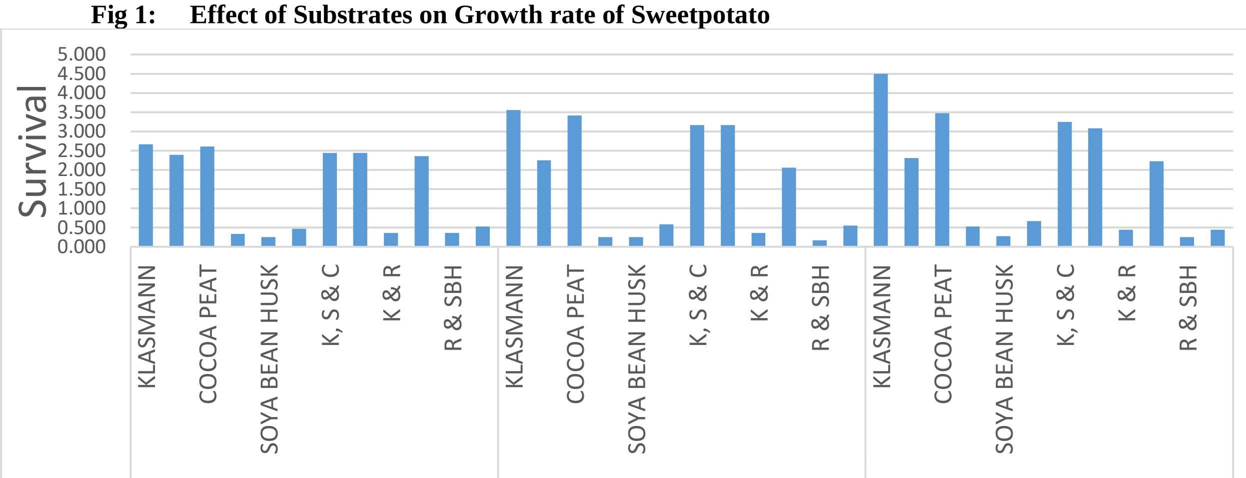

Fig 2: Effect of Substrates on survival rate of Sweetpotato

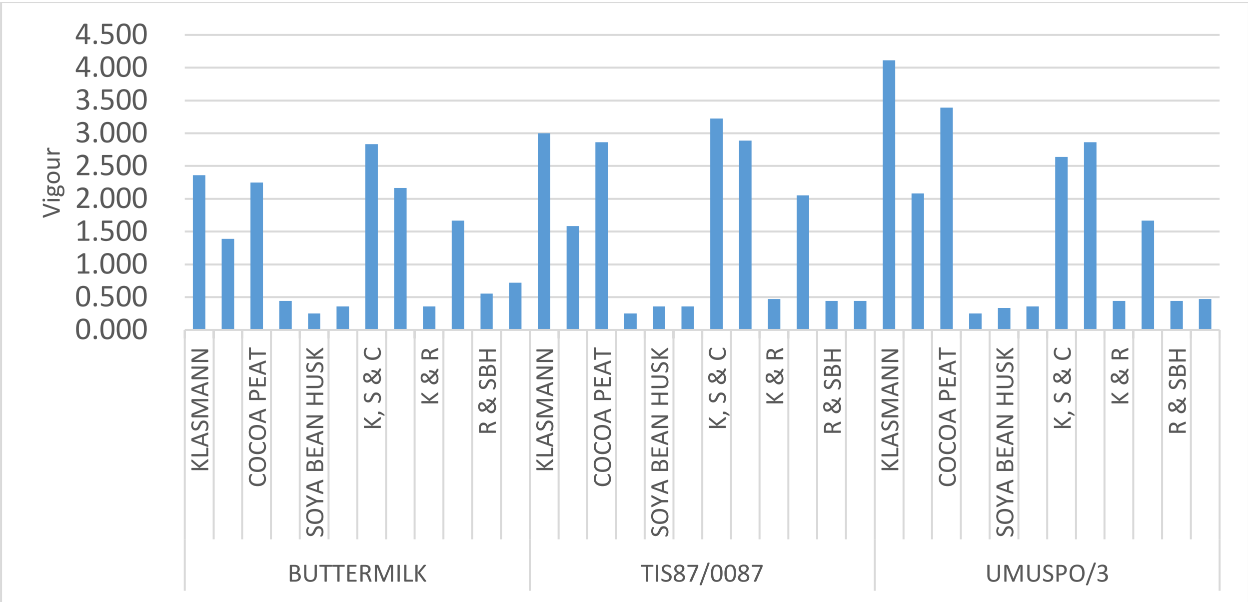

Fig 3: Effect of Substrates on Vigour rate of Sweetpotato

Table 1: **Analysis of variance (ANOVA) of culture (Sweetpotato vines) growth rate, survival rate and vigour rate to variation in Sweetpotato varieties and SAH substrates**

Sources of variation	Df	Growth rate	Survival rate	Vigour
SUBSTRATE	11	1.228***	16.008***	12.339***
GENOTYPE	2	10.947***	0.803**	0.713**
SUBSTRATE:GENOTYPE	21	0.327**	0.314*	0.352***
Residuals	72	0.144	0.158	0.128

CONCLUSION

Based on this study on evaluation of low-cost semi-autotrophic hydroponic substitutes for sweetpotato production, it can be concluded that Coco peat and Soyabean husk can serve as alternatives as well as supplements for Klasmann, to reduce cost of seed multiplication using Semi Autotrophic Hydroponic techniques (SAH).

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COMPARATIVE ASSESSMENT ON EARLY GROWTH OF *KHAYA SENEGALENSIS* AS A FODDER CROP USING ORGANIC AND INORGANIC FERTILIZER

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ABSTRACT
This study compared early growth of Khaya senegalensis as a fodder crop using organic and inorganic fertilizers. Khaya senegalensis seeds were collected and planted in polythene pots using different treatments; Cow dung, Nitrogen and control. The experiment was laid in a completely Randomized Design (CRD) each treatment consist of 16 replicates. Growth parameters measured include; stem height (cm), number of leaf production, collar diameter (cm) and leaf area (cm^2). Data collected were subjected to a one way analysis of variance (ANOVA) and Fishers Least Significant Difference (LSD). Results show that seedling treated with Nitrogen had the highest mean number of leaf production and leaf area with values (13.16) and ($39.44cm^2$) respectively while seedling treated with cow dung had the highest mean stem height (17.07cm) and collar diameter (1.044cm). Results showed no significant difference ($p<0.05$) in stem height, collar diameter and leaf area. However, there was a significant difference ($p<0.05$) in the number of leaf produced. In conclusion, the research revealed that all treatments applied were valuable sources of fertilizer for growth of Khaya senegalensis as a fodder. Both organic and inorganic fertilizers greatly improved growth performance of treated plants over the control. Seedlings treated with Nitrogen demonstrated better growth attributes in terms of foliage production while seedlings treated with cow dung showed greater performance in stem increment which both results indicated Khaya senegalensis as means for fodder crop which is useful to both domestic and wild animals. It is recommended that, either Organic or Inorganic fertilizers can be adopted as a treatment when raising Khaya senegalensis seedlings for fodder crop production.

Keyword: *Khaya senegalensis, Organic and Inorganic fertilizer and growth parameters*

INTRODUCTION
African mahogany (*Khaya senegalensis*) is one of the best known and more frequently used species of forest stands in African and some parts of West Africa (Areolo *et al.*, 2001) e.g Benin, Burkina Faso, Cameroon, Central Africa Republic, Chad, Ivory coast, Gabon, Ghana, Gambia, Mali, Niger, Nigeria, Senegal, Togo, etc. Mahogany and other Meliaceae of Celdrela genus are the backbone of the forest industry in West Africa and the main source of income for large number of people in rural communities (Areolo *et al.*, 2001). The tree is medium sized which can grow up to 15-30cm in height and 1m in diameter. The tree is characterized by leaves arranged in spiral formation clustered at the end of branches. Flowers are sweet scented, fruits changes from gray to black when ripening. Seedlings develop taproot system in deeper soil. Tree may reach a height of 10cm after two to three months with roots about 23cm long. Under normal condition, initial growth is slow, seedlings being 12cm to 23cm tall after two years. Early growth may be much faster (Ayeni, 2011). In Nigeria *Khaya senegalensis* is called Madachi, Oganwa, Ono and Haa in Hausa, Yoruba, Igbo and Tiv languages respectively.
Fodder is an agricultural term for animal feed, *Khaya senegalensis* is a fodder crop which is highly used by both domestic and wild animals as feed. Shoots or sprouts especially tender twigs and stem of woody plants with their leaves, flowers, fruits or pods are raised, managed for livestock feeds. These fodders are also grown to provide nutritional needs of animals. Babayemi and Bamikole (2006) opined that fodder is an important component of

ruminant diet and nutrition for grazing animals in areas where few or are not available (Van *et al*., 2005). Fodder trees are used for livestock production during shortage in pasture especially in terms of extreme climatic conditions such as drought (Franzel *et al.,* 2014; Balehegn *et al.,* 2015). There has been increasing interest in fodder trees and their potentials to help the rural poor as they have a positive effect on milk production in livestock and hence local income generation (Chakeredza *et al.,* 2007; Place *et al.,* 2009). Incorporating this type of trees e.g. *Khaya senegalensis* into agro-silvopastoral systems can also contribute to environmental rehabilitation, improving soil fertility (Moreno and Obrador, 2007). Indigenous fodder trees are multipurpose and provide multiple benefits and services (e.g food, fibre, medicine, fire-wood, etc.) (Balehegn and Eniang, 2009).

Elevitch and Wilkinson (2000) pointed out that fodder trees and shrubs have several application and uses and hence they serves as good sources of Shade, Wind shelter, Life fence, Improved fallow and pasture, Mulch, Bee forage, Human food, Fuel wood, Timber, Fiber resins, Dyes, Tannins, Medicine, Fertility enhancement, Soil stabilization, Beauty, Oxygen, Wildlife habitat, Increases self-sufficiency, Nutrients cycling, Farm diversity etc. Fodder is harvested in the natural environments though (i) Selective cutting of leafy parts, flowers and fruit of shrub and trees. (ii) Pruning of shrubs and trees which are suitable for livestock. (iii) Pollarding of tree crowns (Osemeobo, 2006).

Fertilization with organic and inorganic fertilizer to nursery or forest seedlings is one of the most crucial factors with a positive effect on seedling quality, performance and establishment (Aluko *et al*., 2014). Inadequate management of nursery soil can result in depletion of soil fertility and corresponding reduction in seedlings growth. However, efficient supply of nutrients in proper proportion leads to efficient growth and development of seedlings (Rafiqul *et al*., 2004). Organic fertilizer (cow dung) is rich in microbial diversity, containing different species of bacteria, protozoa and yeast (Randhawa and Kullar, 2011). Inorganic fertilizer (Nitrogen) is an essential aspect of cropping system and these include soil productivity, soil fertility, plant nutrition and qualitative crop yield. The availability of this nutrients to plant contributes to growth and yield. Deficiency of mineral element to plant is evident to poor yield (Raines, 2011). Nitrogen is outstanding among other nutrients; it is required in larger quantities by most crops (Margues *et al.,* 2006). Maintaining adequate fertility of forest nursery soils is of paramount importance to ensure production of high quality planting stock.

METHODOLOGY

The study was conducted at the Nursery unit of the Department of Forestry and Wildlife Management of Modibbo Adama University Yola located between Latitudes; 9^0 20' 32"N and 9^0 20' 36''N and Longitudes; 12^0 30' 18''E and 12^0 30' 21''E. Adamawa State falls under the Sudan, Southern and Guinea Savannah types of vegetation and it experiences distinct dry and wet seasons with temperature ranges from 27^0Cto 40ºC and relative humidity vary with seasons ranges from 20-80% (Adebayo and Tukur, 2010). The wet or rainy season lasts from April to October, and is characterized by single maxima in August and September. During this season, the moisture laden south west trade wind from the Atlantic Ocean blows over the area. Seventy percent of the total rainfall in the area falls within four months of May-September (Adebayo, 2020).

STUDY DESIGN

The experiment was arranged in a Completely Randomized Design (CRD) with three (3) treatments and sixteen (16) replicates. Stem diameter (mm), seedlings height (cm), leaf production and leaf area (cm^2) was assessed. Data were collected every week for a period of (10) weeks on Stem height increment, collar diameter increment, number of leaf production and leaf area. Stem height measurement was taken via the vertical distance from the ground level to the top of each seedling using a measuring rule. Collar diameter was obtained by measuring the diameter at collar points of the seedlings using veneer caliper. While number of leaves on each seedlings was obtained by counting. Finally leaf area was estimated by randomly selecting a leaf from each replicate and determined its area using graph method

Procedure

Fresh seeds of *Khaya senegalensis* seeds were collected from a standing mother tree. Materials used were air dried decomposed Cow dung and River sand were collected from the Nursery section. Materials such as Polythene bags and Inorganic fertilizer (Nitrogen) were obtained from the local market. Top soil was collected few meters beside the nursery in the university compound. Potting mixture was done in the Nursery. The first treatment had a potting mixture of Top soil, River sand and Cow dung at a ratio of 3:2:1. The second treatment had a potting mixture of Top soil and River sand at a ratio of 3:2 of which 0.5g of Inorganic fertilizer (Nitrogen) was added after germination. The third treatment was Control with a potting mixture of Top soil and River sand at a ratio of 3:2 respectively. These treatments were filled into separate polythene pots of 23cm height and 10cm in diameter. Seeds was treated in cold water for 12hours and sown directly into the filled polythene bags. Watering was done twice a day (morning and evening). Other Nursery operations such as weeding were carried out as required throughout the experiment. Measurement commenced a week after the application of Inorganic fertilizer.

Data Analysis

Data collected was analyzed using a one way analysis of variance (ANOVA). Fishers Least Significant Difference was used for the mean separation.

RESULTS AND DISCUSSIONS

Stem height increment

The mean stem height increment recorded from *Khaya senegalensis* seedlings with cow dung, Nitrogen and control, taken at weekly interval for ten weeks is shown in the (Table 1). Mean stem height increment after weeks was highest in seedlings treatment with cow dung (17.07cm) followed by seedling treated with Nitrogen (17.05cm) then the control (16.76cm). ANOVA results in (Table 5) showed that there was no significant difference among treatments.

Table 1. Showing mean stem height increment over a period of ten weeks Treatment (cm)

REPLICATION	TREATMENT 1 (COW DUNG)	TREATMEENT 2 (NITROGEN)	TREATMEENT 3 (CONTROL)
1	17.29	17.54	8.84
2	17.56	17.64	15.92
3	16.01	15.34	20.89
4	13.98	17.75	16.56
5	16.50	22.17	21.54
6	22.25	18.08	14.77
7	17.29	17.20	16.14
8	14.68	18.02	16.90
9	21.41	16.47	15.47
10	15.86	16.40	15.15
11	15.37	17.66	24.53
12	17.02	17.88	14.48
13	14.87	17.02	17.10
14	15.65	13.38	17.20
15	21.35	13.73	16.35
16	16.09	16.51	16.36
SUM	**273.18**	**272.79**	**268.20**
MEAN	**17.07**	**17.05**	**16.76**
VARIANCE	**6.21**	**3.92**	**11.88**

Source: Field work, 2021

Number of Leaf Production

The mean number of leaf production by *khaya senegalensis* seedlings treated with cow dung, Nitrogen and control, taken at weekly interval for ten weeks is shown in (Table 2). Mean number of leaf production after ten weeks was highest in seedlings treated with Nitrogen (13.16) followed by seedlings of the control (12.04) and seedlings treated with cow dung (10.07). ANOVA results (Table 5) showed a significant difference among the treatments ($p<0.05$). LSD conducted showed that there was a significant difference between Nitrogen and cow dung as well as control (Table 6).

Table 2. Showing mean number of leaf production over a period of ten weeks Treatment (cm)

REPLICATION	TREATMENT 1 (COW DUNG)	TREATMENT 2 (NITROGEN)	TREATMEENT 3 (CONTROL)
1	10.40	11.20	9.60
2	12.40	13.30	7.50
3	13.70	9.90	9.90
4	9.80	14.20	9.60
5	10.10	15.90	16.00
6	11.00	14.30	9.60
7	13.50	13.70	15.20
8	9.40	14.20	12.90
9	9.60	16.90	10.90
10	8.90	15.90	9.20
11	8.30	9.50	20.20
12	9.50	18.00	9.20
13	8.90	9.90	13.90
14	8.30	10.40	15.00
15	9.10	12.50	10.70

16	8.20	10.80	13.20
SUM	**161.1**	**210.6**	**192.6**
MEAN	**10.07**	**13.16**	**12.04**
VARIANCE	**3.06**	**7.22**	**11.26**

Source: Field work, 2021

Collar diameter increment

The mean value of collar diameter of *khaya senegalensis* seedlings with cow dung, Nitrogen and control taken at weekly interval for ten weeks is shown in (Table 3). Mean collar diameter after ten weeks was smallest in control with value (0.996cm) followed by seedlings treated with Nitrogen (1.043cm) and was highest in seedlings treated with cow dung (1.044cm). ANOVA result (Table 5) indicated that there was no significant difference among treatments.

Table 3. Showing mean collar diameter increment for the period of ten weeks
Treatment (cm)

REPLICATION	TREATMENT 1 (COW DUNG)	TREATMENT 2 (NITROGEN)	TREATMEENT 3 (CONTROL)
1	1.07	1.03	0.72
2	1.05	1.10	0.82
3	1.23	0.92	1.05
4	0.95	1.08	0.97
5	1.23	1.15	1.10
6	1.14	1.06	0.98
7	1.20	1.15	1.18
8	1.03	1.15	1.09
9	0.92	1.07	1.09
10	0.99	1.08	1.10
11	0.86	0.98	1.12
12	1.01	1.05	0.90
13	1.08	0.95	1.01
14	0.91	0.92	1.06
15	1.09	1.02	0.91
16	0.95	0.99	0.84
SUM	**16.71**	**16.70**	**15.94**
MEAN	**1.044**	**1.043**	**0.996**
VARIANCE	**0.013**	**0.006**	**0.016**

Source: Field work, 2021

Leaf area

The mean value of leaf area of *khaya senegalensis* seedlings with cow dung, Nitrogen and control measured after ten weeks is shown in (Table 4). The mean leaf area after ten weeks was highest in seedlings treated with Nitrogen (39.44cm^2) followed by seedlings treated with cow dung (38.40cm^2) and least in seedlings of the control (35.57cm^2). ANOVA results (Table 5) showed that there was no significant difference among the treatments.

Table 4. Showing means leaf area treatment for the period of ten weeks
Treatment (cm^2)

REPLICATION	TREATMENT 1 (COW DUNG)	TREATMENT 2 (NITROGEN)	TREATMEENT 3 (CONTROL)
1	44.50	48.96	17.88
2	46.64	37.52	46.48
3	31.40	41.00	39.48
4	42.16	36.92	50.68
5	32.84	50.48	25.80
6	26.00	51.12	54.48
7	33.60	24.76	33.56
8	28.52	31.00	32.40
9	48.92	52.72	46.16
10	51.36	36.32	31.72

11	21.24	68.32	32.60
12	32.72	35.76	34.12
13	45.62	25.44	38.48
14	22.64	37.40	34.84
15	55.32	23.56	29.36
16	50.92	29.72	21.00
SUM	**614.40**	**631.00**	**569.04**
MEAN	**38.40**	**39.44**	**35.57**
VARIANCE	**121.50**	**148.58**	**102.70**

Source: Field work, 2021

Table 5. Showing ANOVA values for Growth Parameters Measured

Source	D.F	S.S	M.S	F Value	P Value
Stem height					
Treatment	2	0.959	0.479	0.07	0.9369
Error	45	330.2256	7.339		
Corrected Total	47	313.215			
Leaf Production					
Treatment	2	78.469	39.234	5.47	0.0075
Error	45	323.009	7.178		
Corrected Total	47	401.478			
Collar diameter					
Treatment	2	0.024	0.012	1.0382	0.3624
Error	45	0.529	0.012		
Corrected Total	47	0.553			
Leaf area					
Treatment	2	128.586	64.293	0.52	0.5996
Error	45	5591.559	124.257		
Corrected Total	47	5720.145			

Table 6. Showing Post mortem for number of Leaf Production

t Grouping	Mean	N	TRT
A	13.1625	16	Nitrogen
A			
A	12.0375	16	Control
B	10.0688	16	Cow dung
Least Significant Difference			1.9078
Alpha			0.05

DISCUSSION

The increment of stem height, collar diameter, number of leaves and leaf area of *Khaya senegalensis* seedlings used as a fodder crop due to potting mixture treated with cow dung, Nitrogen and control showed variations in the growth parameters measured. Seedlings grown on cow dung, Nitrogen and control responded differently with regards to the height ($p>0.05$). The result showed that treatments have no significant effects on the seedlings height. This implies that there could be no need for different treatment when raising fodder crop e.g *Khaya senegalensis* with regards to stem height. The result on stem height increment agrees with the study of (Arnold, 2004), who reported that organic fertilizer gradually release more nutrients to species over a longer time which enable fodder crops to develop for consumption unlike inorganic fertilizer which release nutrient within shorter period for seedling growth.

Application of cow dung and Nitrogen in relation to control responded differently with regards to leaf production ($p>0.05$). The result showed that there is a significant difference between Nitrogen and cow dung. *Khaya senegalensis* seedlings used as a fodder crop treated with Nitrogen recorded highest mean number of leaves. This showed the essential of Nitrogen in vegetative growth of crops. Seedling treated with cow dung recorded the least number of leaves and leaf spot disease was also observed. This may be due to high dose of cow dung and some other inherent chemicals such as Phosphorus since excess absorption of Phosphorus can affect regular functioning of organs in trees, shrubs, herbs, fodder etc. This result is in conformity with the study of (Saka *et al.*, 2008) who reported that seedlings treated with cow dung had the least mean number of leaves. This indicated that the species which are used as a fodder can be best raised with Nitrogen.

Results of the potting mixture which is treated with Nitrogen, cow dung and control responded differently ($p<0.05$) with regards to collar diameter of *Khaya senegalensis* seedlings. The result indicated that the various treatments did not significantly increase collar diameter of fodder crop (*Khaya senegalensis* seedlings). Seedlings treated with cow dung had the highest mean stem diameter compared to Nitrogen and control seedlings. Collar diameter showed a better response to cow dung in the initial development phase. Stem diameter is one of the important parameter to estimate survival of seedlings after planting of forest species. This result agrees with (Afonso *et al*., 2017). However, the result implies that there could be no need for application of fertilizer when raising *Khaya senegalensis* seedling in terms of stem height, this may be due to organic manure which may contain recalcitrant element which affect the growth and development.

Based on the treatments, variation in leaf area of *Khaya senegalensis* seedlings, Nitrogen had the best mean leaf area ($p<0.05$). Results showed that various treatments did not significantly increase leaf area. Seedlings treated with Nitrogen had the best mean leaf area. This could also be as a result of comparatively higher Nitrogen concentration in potting mixture treated with Nitrogen which is more of enhancement in the vegetative growth of seedlings.

CONCLUSION

From the results of this study, it is revealed that all treatments applied were valuable sources of fertilizer for the growth of *Khaya senegalensis.* They greatly improved growth performance of plants over the control. Seedlings treated with Nitrogen demonstrated better growth for large fodder production and leaf area compared to cow dung. However, seedlings treated with cow dung showed better growth rate in terms of stem height and collar diameter. The results also attest that *Khaya senegalensis* can be grown for successful plantation establishment for the growing of fodder crop which can be utilized using both organic and inorganic fertilizer based on the objective or focus of management. Organic fertilizer performed better in terms of stem growth while inorganic fertilizer proved to be better in foliage production.

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GROWTH RESPONSE OF LOWLAND RICE (ORYZA SATIVA L.) VARIETY TO PLANTING METHOD AND FERTILIZER MANAGEMENT AT SAMARU, NIGERIA

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ABSTRACT
Field trials were conducted at Institute for Agricultural Research, Samaru, and Irrigation Research Station, Kadawa in the northern Guinea and Sudan Savanna ecological zones of Nigeria respectively, during the 2021 wet season. Treatments consisted of three lowland rice varieties (FARO 44, FARO 52, and FARO 57), three planting methods (dibbling, drilling and broadcasting) and four rates of NPK and Agric-Zyme 3X organic liquid fertilizers (0:0:0 kg NPKha^{-1} + 3.0 lha^{-1}, 60:30:30 kg NPKha^{-1}+1.5lha^{-1}, 60:30:30 kg NPKha^{-1} + 3.0 lha^{-1} and 120:60:60 kg NPKha^{-1} + 0 lha^{-1}). The trials were replicated three times, in a factorial arrangement using split plot arrangement. Fertilizer rates and planting methods were the main plots and rice variety as subplot. FARO 44 recorded shorter plants heights and higher net assimilation rates, but took fewer days to 50 % flowering than FAROs 52 and 57. Effect of planting methods was generally not significant on rice, however, broadcasting recorded higher leaf area index, while dibbling recorded higher paddy yield. Application of 120: 60: 60 NPK kg ha^{-1} alone out-performed other fertilizer management methods followed by 120: 60: 60 NPK kg ha^{-1} +1.5 l ha^{-1} Agric-Zyme 3X in all parameters alone. In conclusion, FARO 57 variety out-performed other varieties used in the study, Drilling method and application of 120: 60: 60 NPK kg ha^{-1} alone were better for growth, yield and grain quality of lowland rice in the study areas.

Keywords: *Growth Response, Lowland Rice, Variety, Planting method and Fertilizer management*

INTRODUCTION
Rice (*Oryza Sativa*) is a staple food in many countries of Africa and other parts of the world. Imolehin and Wada, (2000) reported that rice is the second most important cereal in the world in terms of production, after wheat. West Africa accounts for 64.2 % and 61.9 % of total rice production and consumption respectively in sub-Saharan Africa, with Nigeria ranking first in both production and consumption (Imolehin and Wada, 2000**)**. Nigeria is currently the largest rice producing country in Africa. Traditional rice varieties are tall, have a long growth and maturation periods (5-6 months) and low yields (1.5-2.0 t ha^{-1}) tons per hectare. Improved varieties are shorter (less than 50 cm) and are more responsive to fertilization with short growth duration and higher yields (3.5-5 t ha^{-1}), (Mohammed, 2016). Improper sowing techniques usually affects yield potentials of the rice crop. Sowing of improved varieties using appropriate methods of seeding could produce a fast growing and uniform crops with higher yields which could compete weeds more efficiently (Kawure *et al.*, 2018). This study was therefore, conducted to identify suitable varieties and appropriate planting methods and fertilizer management in rice.

MATERIALS AND METHODS
Field trials were conducted at the Institute for Agricultural Research, Samaru, in the Northern Guinea and Sudan Savanna ecological zones of Nigeria, during 2021 wet season. Treatments consisted of three lowland varieties (FARO 44, FARO 52, and FARO 57), four rates of combined NPK and Agric zyme 3X organic liquid fertilizers (0:0:0 kg ha^{1} plus 3lha^{-1}, 60:30:30 kg NPKha^{-1}plus 1.5lha^{-1}, 60:30:30 kg NPKha^{-1} plus 3lha^{-1} and 120:60:60 kg NPKha^{-1} plus 0lha^{-1}), and three planting method (dibbling, drilling and broadcasting). These studies were designed as Randomized Complete Block Designs, laid out in split plots arrangements with fertilizer rates and planting methods as main plot and lowland rice varieties as sub plots. Gross and net plot sizes were 3.0 m x 4.0 m (12 m^2) and 2 m x3 m (6 m^2) respectively. The treatments were replicated three times. The experimental site was harrowed twice to obtain a fine tilth and marked out into plots (basins) and replicates Each main plot was separated by 1 m pathway, the sub-plot by 0.5 m. Seeds were sown according to treatments. Dibbling, at 20 cm inter and intra row spacings using 60 kg ha^{-1} seed rate, while seeds were drilled in grooves 2-3 cm deep at 20 cm spacings using 80

kg ha^{-1} seed rate. Seeds were manually sown at at 100 kg ha^{-1} and covered lightly with soil. The crop was harvested at maturity when the entire plants turned yellowish or golden brown, using sharp locally made handheld sickles. Harvested plants were threshed. Growth data were collected on plant height (cm), leaf area index, net assimilation rate, days to 50 % flowering at 3, 6, 9 and 12 weeks after sowing effective grain-filling period and paddy yield.

RESULTS AND DISCUSSION

Details of physical and chemical properties of the soil taken at the experimental sites (Samaru and Kadawa) at a depth of 0-30 cm in 2021 wet seasons are shown in Table 1. The soils were identified as loamy and sandy loam for Samaru and Kadawa respectively. In both locations, soil pH were slightly acidic (pH of 5.67 and 6.25), moderate in organic carbon (14.62 and 16.85 gkg^{-1}), and total nitrogen (1.68 and 1.95 gkg^{-1}) respectively, and low in available phosphorus (14.20 and 16.10 mgkg^{-1}). Exchangeable cations were low (K = 0.16 and 0.19 cmolkg^{-1}, mg 0.58 and 0.62 cmolkg^{-1}, Ca 3.02 and 3.55 cmolkg^{-1}, Na 0.25 and 0.27 cmolkg^{-1}, Al^{+++}+ H^{+} 0.8 and 0.6 and low CEC 4.81 5.25 cmolkg^{-1} respectively, were moderate for both locations, in the 2021 wet season. Chandrasekaran *et al*. (2007) reported that rice can be grown successfully on a variety of soils, the most important requirement been its ability to hold moisture. Plant height of lowland rice varieties as influenced by planting methods and fertilizer management at Samaru and Kadawa, did not differ significantly (Table 2). However, at Samaru, application of 120: 60: 60 NPK kg ha^{-1} + 0 Agric-Zyme 3X l ha^{-1} recorded taller ($p< 0.05$) plants followed by combined application of 60: 30: 30 NPK kg ha^{-1} + 1.5 Agric-Zyme 3X l ha^{-1} while application of 3 Agric-Zyme 3X l ha^{-1} alone recorded shortest ($p< 0.05$) plant heights. At Kadawa application of 60: 30: 30 NPK kg ha^{-1} + 1.5 Agric-Zyme 3X l ha^{-1} recorded taller plant height, but was statistically similar with 120: 60: 60 NPK kg ha^{-1} + 0 Agric-Zyme 3X l ha^{-1} and 60: 30: 30 NPK kg ha^{-1} + 1.5 Agric-Zyme 3X l ha^{-1}. Similarly, application of 3 Agric-Zyme 3X l ha^{-1} alone recorded shorter plants and was also statistically similar with 120: 60: 60 NPK kg ha^{-1} + 0 Agric-Zyme 3X l ha^{-1} and 60: 30: 30 NPK kg ha^{-1} + 1.5 Agric-Zyme 3X l ha^{-1}. Varietal variations and effect of planting methods were not significant ($p< 0.05$) on leaf area index at both locations. Effect of fertilizer management on leaf area index (LAI) was significant across locations and seasons. At Samaru application of 120: 60: 60 NPK kg ha^{-1} recorded higher leaf area index, followed by 60: 30: 30 NPK kg ha^{-1} + 1.5 Agric-Zyme 3X l ha-^{1} and 60: 30: 30 NPK kg ha^{-1} + 3.0 Agric-Zyme 3X l ha-^{1} which were statistically similar ($p< 0.05$) and 3.0 Agric-Zyme 3X l ha-^{1} alone recorded lower leaf area index. At Kadawa, application of 60: 30: 30 NPK kg ha^{-1} + 1.5 Agric-Zyme 3X l ha-^{1} and 60: 30: 30 NPK kg ha^{-1} + 3 Agric-

Table 1: Physio-chemical characteristics of the experimental sites during the 2020 wet season at Samaru and Kadawa.

Soil depth 0-30cm		
	Samaru	**Kadawa**
Soil Composition	**2021**	**2021**
Particle size (g/kg)		
Clay		
Silt		
Sand		
Textural class		
Chemical Properties		
pH in water		
pH in 0.01m$CaCl_2$		
Organic carbon gkg^{-1}		
Available P (gkg^{-1})		
Total nitrogen (gkg^{-1})		
Exchangeable Cation (cmolkg^{-1})		
K (cmolkg^{-1})		
Mg (cmolkg^{-1})		
Ca (cmolkg^{-1})		
Na (cmolkg^{-1})		
Al^{+++}+ H^{+} (cmolkg^{-1})		
CEC (cmolkg^{-1})		

Source: Soil analytical laboratory, Agronomy Department, Faculty of Agriculture, ABU, Zaria.

Zyme 3X l ha-^{1} and 120: 60: 60 NPK kg ha^{-1} alone were statistically similar and recorded higher leaf area index, while 3 Agric-Zyme 3X l ha-^{1} recorded lower leaf area index. The three varieties did not differ significantly ($p< 0.05$) in their leaf area indices in both locations while both drilling and dibbling recorded similar but lower indices than broadcasting at Samaru only (Table 2). Application of 120:60:60 kg ha^{-1}NPK alone recorded highest ($p< 0.05$) leaf area index in both locations followed by combined application of NPK and Agric-Zyme 3X (Samaru) and Agric-Zyme 3X alone (Kadawa). FAROs 44 and 57 recorded similar and higher ($p< 0.05$) net assimilation rates than FARO 52 at Samaru. However, FARO 52 variety was also statistically similar ($p < 0.05$) with FARO 57. Planting method had no significant effect on net assimilation rates at both locations. At both Samaru and Kadawa, application of 120:60:60 kg ha^{-1} NPK alone or 60:30:30 with 1.5 l ha^{-1} Agric-Zyme 3X registered statistically similar ($p < 0.05$) and higher net assimilation rates than other fertilizer management rates. FARO 44 took shorter ($p < 0.05$) days to attain 50 % flowering followed by FARO 52, while FARO 57 took relatively longer ($p < 0.05$) days to flower. Paddy yields of three varieties were statistically similar ($p < 0.05$) at both locations, while dibbling, followed by broadcasting out-yielded drilling in paddy at Kadawa. Application of Agric-Zyme 3X alone at Samaru recorded least ($p < 0.05$) paddy yield than other fertilizer management methods. Similar trend was observed at Kadawa. Treatments interactions on all parameters assessed were not significant. The contrasting varietal responses (largely non-significant) observed on growth parameters and paddy yield is supported by Islam *et al.*, (2010), who reported that varieties with longer growth duration produced higher grain yields than varieties with shorter growth duration. Usman *et. Al.*, (2022) reported that FARO 44, is an early maturing variety. This conforms with these findings, while Fasina and Adeyanju, (2006) reported that FARO 52 was a medium maturing rice variety. Djomo *et al.*, (2017) observed that application of N-P-K fertilizer increased growth parameters such as height. They recorded higher leaf area index, ant this agrees with Gala *et al.*, (2011), who reported that increasing amount of NPK improved considerably, the vegetative growth of rice. The larger the leaf area of a plant the more the photosynthetic area and consequently, the output. Wu *et al*. (1998) reported similar results on increasing rates of N, P, and K fertilizers favoured vigorous growth of the rice plant. Higher number of tillers gave more panicles consequently translating to higher paddy yields.

Table 2: Plant height, leaf area index, net assimilation rate, days to 50% flowering and paddy yield of lowland rice varieties as influenced by planting method and fertilizer management at Samaru and Kadawa, 2021 wet season

Treatment	Plant height (cm)		Leaf area index		Net assimilation rate (g cm wk^{-1})		Days to 50% flowering		Paddy yield (kg ha^{-1})	
	Samaru	Kadawa	Samaru	Kadawa	Samaru	Kadawa	Samaru	Kadawa	Samaru	Kadawa
Variety										
FARO 44	39.694	53.778	2.800	1.389	0.742a	0.912	87.444c	85.778c	1806.0	2588.0
FARO 52	42.306	52.617	2.955	1.504	0.436b	1.108	90.889b	90.111b	1881.5	2754.6
FARO 57	41.389	53.300	2.882	1.624	0.593ab	0.962	103.611a	104.500a	1850.5	2606.5
SE±	1.109	0.667	0.109	0.114	0.099	0.103	0.748	0.744	86.594	114.779
Planting method										
Dibbling	39.815b	53.667	2.700b	1.596	0.669	0.873	93.750	93.056	1961.6	3106.5a
Drilling	39.204b	53.356	2.638b	1.479	0.681	1.081	93.361	92.972	1758.3	2236.1c
Broadcasting	44.370a	52.672	3.299a	1.443	0.421	1.028	94.833	94.361	1818.1	2606.5b
SE±	1.109	0.667	0.109	0.114	0.099	0.103	0.748	0.744	86.594	114.779
Fertilizer management (NPK kg ha^{-1} + Agric-Zyme 3X L ha^{-1})										
0: 0: 0 + 3	28.296d	51.256b	1.642c	0.980b	0.279c	0.853ab	90.963c	94.148ab	1603.1b	1765.4c
60:30:30 + 1.5	43.790b	54.978a	3.124b	1.745a	0.866a	1.168a	93.333bc	93.407ab	1885.8ab	3037.0a
60:30:30 + 3	40.099c	53.467ab	2.837b	1.511a	0.464bc	0.764b	93.667b	91.704b	1969.8a	2543.2b
120: 60:60 + 0	52.333a	52.956ab	3.913a	1.788a	0.753ab	1.191a	97.963a	94.593a	1925.3a	3253.1a
SE±	1.281	0.770	0.127	0.131	0.115	0.119	0.863	0.859	99.993	132.540
Interaction										
P x V	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x V	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
P x F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
P x F x V	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) within treatment group are not significant at 5% level of probability. NS= not significant, **= significant at 1%, *= significant at 5% level of probability, WAS week after Sowing, NPK= Nitrogen phosphorus potassium, Agric-Zyme 3X= Organic Liquid Fertilizer.

CONCLUSION

In conclusion, FARO 57 variety out-performed other varieties, drilling method and application of 120: 60: 60 NPK kg ha^{-1} alone were better for growth, yield and grain quality of lowland rice in the study area.

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COMPARATIVE EFFECTS OF PLANTING METHODS ON GROWTH AND YIELD OF SESAME (*SESAMUM INDICUM* L.) AT LAFIA, NASARAWA STATE, NIGERIA

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ABSTRACT
A field trial was conducted in the 2015 and 2016 cropping season to determine the performance of Sesamum indicum L. (Beniseed) on the growth and yield of sesame at two planting methods at Lafia-Nasarawa state. The planting methods were broadcasting and dibbling, at 3 different levels (10 cm x 10 cm, 20 cm x 20 cm ,and 30 cm x 30 cm). At the growth stages of sesame broadcasted plots had spindle stems and were taller but plants on the dibbling plots had comparatively wider or thicker stems. However, at harvest the plants in the dibbled plots produced significantly higher (p<0.05) seed yield and higher 1000 seed weight per plot than the sesame plants on the broadcasted plots.
Keywords: *Sesame, planting methods, broadcasting, dibbling*

INTRODUCTION
Sesame belongs to the Family Pedaliaceae and is one of the most ancient seed and oil seed crops known to man. It was a major oil seed crop in the ancient world due to easiness of extraction, stability, and resistance to drought. It is cultivated in almost all tropical and sub-tropical African and Asian countries, mainly for its highly nutritious and edible seeds. In Nigeria , it is cultivated in the dry, Northern and Southern Guinea, Sudan and Sahel savannah zones. Sesame has diverse usages and contains 42 – 45 % oil , 20 % protein and 14 – 20 % carbohydrate (Bari , 2004).

Despite the nutritional and socio-economic roles played by sesame, the crop is still facing constraints in terms of application of agronomic practices (correct planting pattern and fertilizer rates that will enable the farmers have better growth and yield of the crop). Presently, the crop is planted by merely broadcasting the seeds on the field, and this appears not to be a good method of planting.

With the socio-economic and nutritional roles played by sesame in Nigeria, sesame it is important to determine more appropriate planting methods that may ensure earlier and better emergence than merely broadcasting seeds on the field as currently practiced in the major sesame producing areas of Nigeria . In Nasarawa state, the only method of planting used by farmers is broadcasting. This and other factors could be responsible for the low yield of sesame. Therefore, to have higher yield of this crop, the application of better planting methods is imperative.

MATERIALS AND METHODS
The field trial was carried out at the Teaching and Research Farm of College of Agriculture Lafia-Nasarawa State, during the wet seasons of 2015 and 2016, in the Southern Guinea Savannah zone of Nigeria. Data on rainfall distribution, maximum and minimum temperatures and relative humidity of the study area for the two years were obtained from the Nigerian Meteorological Agency (NIMET) of the Federal Ministry of Aviation, Lafia office. The soil of the area has been classified to be sandy loam and characterised by low N, P and K as shown in the soil textural and chemical analyses - table 1.

The experimental design used was Randomised Complete Block Design (RCBD), replicated three times. Treatments consisted of two planting methods of broadcasting and dibbling at 3 levels (10 cm x 10 cm , 20 cm x 20 cm and 30 cm x 30 cm). Plots were first cleared and then, harrowed. The area was then mapped out into plots of 9 m^2 each. The plots were arranged side by side in rows of three blocks with each row having 4 plots. The space between blocks was 1 m apart, while the space between plots within a block was 50 cm. Sesame seed variety E8 was got from the Seed Store of Nasarawa state Agricultural Development Programme, Lafia.

The seeds were then sown at a depth of 3-4cm and seeds uniformly spaced and spread on the broadcast plots. The sesame seedlings on the spaced treatments were thinned to 3 plants per stand after 3 weeks of sowing. Weed, pest and disease control and other agronomic practices were applied at 4 weeks after sowing. Five sampled plants were randomly chosen from each plot and tagged for data collection. From the five tagged plants, growth parameters (plant height and stem diameter), were taken fortnightly, while yield parameters (seed yield per treatment and 1000 seed weight per treatment) were recorded. Analysis of variance (ANOVA) was carried out to test for significance between treatment means using F-test as described by Snedecor and Cochran (1967). Where significant differences occurred, Fisher's least significance difference (F-LSD), was used to separate means.

Table 1: Physical and chemical analyses of soil before planting Soil properties at 0 - 30cm depth.

Soil properties	Value
Physical composition	
Clay (g/kg)	8.64
Silt	11.14
Sand	80.22
Textural class (USDA)	Sandy loam
Chemical composition	
pH (H_2O)	5.18
pH ($0.01MCaCl_2$)	5.04
TN%	0.13
Avail. P (ppm)	18.08
K (mg/kg)	0.16
OC (mg/kg)	0.42
C/NC	3.23
Mg (mol/kg)	1.45
Ca (mol/kg)	2.21
Na (mol/kg)	0.85
CEC (mol/kg)	4.67

RESULTS AND DISCUSSION:

Table 2 below shows the effect of planting methods on growth and height on sesame in 2015 and 2016 seasons. During the 2-year period of research, broadcasting method of planting sesame produced plants that were significantly ($p<0.05$) taller than those planted by dibbling particularly at 12 WAS (76.60 cm). This indicated that sesame planted by broadcasting grew taller with spindle stems than those planted by dibbling. This result also showed that planting sesame at closer spacing and broadcasting leads to production of taller plants due to competition for space, sunlight.

Plant Height (cm)

Table 2: Effect of planting methods on growth height of sesame in 2015 and 2016 rainy seasons

	Plant height (WAS)									
Planting methods	**4**		**6**		**8**		**10**		**12**	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Broadcasting	8.72	8.04	22.0	21.9	56.10	59.70	72.77	72.31	74.40	84.60
Dibbling										
10 cm x 10 cm	8.88	8.30	21.87	20.50	45.61	29.90	43.78	41.30	45.56	41.40
20 cm x 20 cm	9.59	8.21	23.69	21.20	46.24	33.90	44.45	43.90	46.45	43.90
30 cm x 30 cm	10.13	8.54	24.97	19.66	49.66	31.50	51.75	38.40	58.85	40.80
LSD (0.05)	1.53		3.30		7.82		2.12		5.22	

Table 3 shows effect of planting methods on stem diameter of sesame in 2015 and 2016. Broadcasting produced sesame plants with spindle stems. Dibbling. All the 3 levels of dibbling produced sesame plants with significantly ($p<0.05$) wider or fatter stem diameter than in broadcasting. This result tallies with that by Umar Bako, (2014) who reported that under wider spacing (30 cm x 45 cm or 30 cm x 60 cm). and that with wider spacing, the were less populated with little or no etiolation was experienced by plants in such plots .

At 12 week, sesame planted by dibbling at a spacing of 20 cm x 20 cm gave plants with significantly ($p<0.05$) wider diameter than those planted at 10 cm x 10 cm apart. Also in 2016, at 12 weeks, spacing at 30 cm x 30 cm produced plants whose stem diameter that were statistically similar ($p<0.05$) with those planted at 20 cm x 20 cm.

Table 3: Effects of planting method on the stem diameter of sesame for 2015 and 2016 rainy seasons

Planting methods	Stem Diameter (WAS) 4		6		8		10		12	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Broadcasting	0.26	0.29	0.37	0.39	0.42	0.41	0.45	0.43	0.47	0.48
Dibbling										
10 cm x 10 cm	0.31	0.36	0.39	0.40	0.47	0.49	0.55	0.51	0.52	0.53
20 cm x 20 cm	0.38	0.41	0.43	0.46	0.49	0.51	0.58	0.52	0.61	0.62
30 cm x 30 cm	0.38	0.40	0.46	0.51	0.50	0.53	0.61	0.64	0.63	0.65
LSD (0.05)	0.09		0.09		0.07		0.01		0.07	

Sesame Seed Yield per Treatment(g):

Table 4 below shows effect of broadcasting and levels of dibbling on the growth and yield of sesame, in 2015 and 2016 growing seasons, The mean seed yield produced per plot by broadcasting method were 3088.52 g and 3098.20 g respectively. Comparatively, the seed yield of sesame planted at 10 cm x 10 cm was significantly higher (p<0.05) than those produced by broadcasting in both years. There was significant differences (p<0.05), between yields of all the 3 levels of dibbling and the yields obtained from broadcasting. Dibbling was significantly higher (p<0.05) than that of broadcasting. This result is in harmony with Akbar, *et al.*, (2001) who worked on 2 varieties of sesame (Punjab—89 and TS -3) and concluded that their seed yields were significantly influenced by planting pattern in both varieties. Also, Arunachalam (2010), reported gradual reduction in seed yield of sesame from 279 kg to 184 kg /ha with increase in plant population from200,000 to 400,000 plants per hectare.

Table 4: Effect of planting methods on Seed yield of sesame per treatment for the 2015 and 2016 wet seasons.

Planting method	Year	
Broadcasting	2015	2016
	3088.52	3098.20
Dibbling		
10 cm x 10 cm	3175.93	3361.30
20 cm x 20 cm	3185.19	3465.01
30 cm x 30 cm	3193.52	3470.20
LSD (0.05)	37.7	37.40

One Thousand Sesame Seed Weight(g):

Table 5 shows the effects of broadcasting and 3 levels of dibbling on 1000 seed weight of sesame. The 1000 seed weight for sesame planted by broadcasting is 2.88 g and 3.04 g respectively. However, the 1000 seed weight produced by sesame at all the 3 levels of dibbling in 2015 was significantly higher (p<0.05), than that of broadcasting. In 2016 , the 1000 seed weight produced by sesame at 20 cm x 20 cm and 30 cm x 30 cm apart were significantly higher (p<0.05), than that produced by broadcasting. This result is also in harmony with that reported by Akbar *et al.*, (2010), who reported that 1000 seed weight was significantly affected by planting patterns.

Table 5: Effect of planting methods on 1000 sesame seed weight for 2015 and 2016 wet seasons

Planting method	Year	
Broadcasting	2.88	3.04
Dibbling		
10 cm x 10 cm	3.81	4.01
20 cm x 20 cm	3.82	4.90
30 cm x 30 cm	3.83	4.95
LSD (0.05)	0.09	1.02

CONCLUSION AND RECOMMENDATION:

The result of this two-year research has shown that sesame planted by dibbling performed better than that by broadcasting. It is therefore, recommended that dibbling be used in planting sesame to optimise yield and consequently, income.

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EFFECT OF APPLICATION OF CATTLE DUNG ON GROWTH AND YIELD OF TURMERIC *(CURCUMA LONGA* L.*)* IN THE RAIN FOREST ZONE OF NIGERIA

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ABSTRACT
Afield experiment was carried out in the rain forest zone of Nigeria at Akwa Ibom State University Teaching and Research Farm, Obio Akpa Campus in April 2021, to assess effect of varying rates of cattle dung on growth and yield of Turmeric (Curcuma longa L.). The experimental design was a Randomized Complete Block Design, comprising five (5), treatments replicated four times. The treatments (rates of cattle dung) were 1.0, 2.0, 3.0, 4.00 and control (0 t/ha). Data were collected for growth and yield parameters and subjected to analysis of variance. Significant means were separated using Fisher's least significant differences at 5 % level of probability. Results indicated significant differences (p<0.05) on turmeric height (cm), number of leaves/plants, leaf area at 2, 4, 6 months after planting (MAP), number of rhizomes/plant, number of tillers/plant, tiller lengths and weight of rhizomes (t/ha) respectively. Application of 4.0 t/ha of cattle dung, gave statistically higher (p<0.05) values on plant height, number of leaves/plant and leaf area at 2, 4, 6 MAP. The least values (p<0.05) were obtained at 1.0 t/ha when and control. With 4.0 t/ha application of cattle dung, number of rhizomes/plant (5.75), number of tillers/plant (5.92), length of tillers (25.41 cm) and the yield (18.44 t/ha) were higher (p<0.05) compared with the control (2.24, 2.43, 17.20 cm, 6.75 t/ha..
Keywords: *Turmeric, rhizomes, tillers, cattle dung.*

INTRODUCTION
Turmeric (*Curcuma longa* L.) is an important and common spice crop used for many years (Chattopadhyay *et al.*, 2004; Kikusawa and Reid, 2007). It was first used as a dye and then later for its supposed properties in folk medicine (NCCIH, 2012). The plant grows up to 1 m with a short stem, tufted leaf with yellow flowers between 10-15 cm in length (Udoh *et al.*, 2005). The rhizomes are yellowish-brown with a dull orange interior that looks bright yellow when powdered (Jajji, 2012). It contains appreciable quantities of proteins (6.3 %) lipids (5.1 %), carbohydrates (69.4 %) and fibre (2.6 %). Turmeric is rich in minerals like phosphorus, calcium, iron and vitamin A (Udoh *et al.*, 2005). Among spice crops, turmeric is popular and used on a large number of food items (Rachman *et al.*, 2010; Ishimine *et al.*, 2003). It also shows anti-bacterial, anti-fungal, anti-ulcer and anti-cancer effect. It can be grown on different types of soils, but it thrives best in well-drained, fertile, sandy and loamy soils with a pH range of 4.5-7.5. It cannot stand water stagnation or alkalinity (Akpan *et al.*, 2021).
Cattle dung (cow pats, cow pies or cow manure) is a waste product of bovine animal species. These species include domestic cattle, bison and water buffalo. Cattle dung is the undigested residue of plant matter which has passed through the animal's gut and the resultant faecal matter is rich in minerals. Cattle dung manure is presumed to be an excellent fertilizer, rich in organic matter (contains about 3 % nitrogen, 2 % phosphorus and 1% potassium (N.P.K 3-2-1, high levels of ammonia and potentially dangerous pathogens, hence the recommended bagging or composting prior to its use as cow manure or fertilizer. It can improve soil moisture-holding capacity when mixed with the soil and further improves aeration helping to break-up compacted soil (Ummul, 2021). The objective of this study was to evaluate the effect of cattle dung application on the growth and yield of turmeric in the rain forest zone of Nigeria.

MATERIALS AND METHODS
The research was conducted at the Akwa Ibom State University Teaching and Research Farm Obio Akpa Campus in Oruk Anam Local Government Area, Akwa Ibom State in Nigeria. The experimental design was a Randomized Complete Block (RCBD), with five treatments (cow dung at 1.0, 2.0, 3.0, 4.00 and 0 t/ha), and three replications.

Each plot measured 3 x 4 m with 1 m alleyways, with an area measured 23 x 16 m. Deep ploughing were made in beds of 15 cm height spaced 1 m apart. Planting was done with carefully preserved and selected rhizomes using an Africa hand-held hand hoe at spacing of 50 x 50 cm and covered. The cattle-dung manure was sun cured for about 3 days, pulverized before application and applied uniformly in band at sixty days after planting. Weeds were removed manually at intervals of 60, 90 and 120 days after planting, while harvesting of the rhizomes was done at 8 MAP when the leaves turned yellow and dried. Harvested turmeric rhizomes were cleaned of soil, mud and other extraneous matter. The following growth and yield parameters were collected: height, number of leaves per plant and leaf area for the growth parameters. Number of rhizomes/plant, number of tillers/plant, length of tillers and weight of rhizomes (t/ha) were collected for as yield parameters. All data were subjected to analysis of variance (ANOVA). Significant means were separated using Fisher's Least Significant Difference.

RESULTS

The effect of different rates of cattle dung application on the plant height of turmeric is shown in Table 1. The result showed significant differences ($p<0.05$) on height of plant at 2, 4, 6 months after planting (MAP) . With increase in the tonnage of cow droppings application, there was a corresponding increase in the growth parameter such as plant height. At 2, 4 and 6 MAP, higher values of plant height (33.52, 52.50 and 60.25 cm respectively) were recorded with 4.0 t/ha treatment. This was followed by 3.0 t/ha (27.09, 48.91 and 55.92 cm). The least values were obtained at 1.0 t/ha.

Table 2 shows the effect of different rates of cattle dung application on number of leaves of turmeric plant. Result indicated significant differences ($p<0.05$) in that 4.0 t/ha, gave higher number ($p<0.05$) of leaves (6.20, 24.61, 27.13) at 2, 4, 6 MAP respectively. This was followed by 3.0 t/ha (6.01, 22.17 and 24.06) at 2, 4, 6 MAP.

Table 3 shows effect of different rates of cattle dung application on the leaf area of turmeric. Results indicated that at 2, 4 and 6 MAP, higher ($p<0.05$) values (63.72, 197.01 and 201.43 cm^2) were obtained for the 4.0 t/ha. At 3.0 t/ha, values of 58.31, 196.30 and 199.47 cm^2 were obtained at 2, 4 and 6 MAP respectively. The least value 46.30, 107.50 and 122.51 cm^2 were obtained with 1.0 tonne/ha in comparison to the control treatment (34.61, 81.72 and 93.22 cm^2).

Number of rhizomes per plant as affected by the different rates as shown in Table 4. At treatment of 4.0 t/ha, the number of rhizomes was higher ($p<0.05$) (5.75), followed by 3.0 t/ha (5.22) and 2.0 t/ha (4.36). The least recorded number of rhizomes was obtained at 1.0 t/ha (3.52). It was further observed that higher yields were obtained with higher quantities of organic fertilizer. Number of tillers per plant as influenced by different rates of cattle dung are presented in Table 4. 4.0 t/ha, produced significantly higher ($p<0.05$) number of tillers per plant (5.92). This was followed by 5.71 and 5.26 recorded at 3.0 t/ha and 2.0 t/ha respectively. The least number of tillers per plant (3.91) was recorded at 1.0t/ha. Length of tillers per plant as influenced by different rates of cattle dung application is shown in Table 4. The result showed significant differences ($p< 0.05$). The significantly longer ($p<0.05$) tillers (25.41 cm) was recorded at 4.0 t/ha. The shortest tiller of 17.20 cm was recorded in the control treatment. Yield of turmeric (t/ha) as influenced by different rates of cattle dung application is shown in Table 4. At 4.0 t/ha, significant higher ($p<0.05$) rhizomes (18.44 t/ha) were recorded. 3.0 t/ha 18.25 t/ha, while the least ($p<0.05$) rhizome yield (6.75 t/ha) was recorded in the control treatment.

Table 1: Effect of different rates of cattle-dung application on the height (cm) of Turmeric

Treatment (tons/ha)	Months After Planting (MAP)		
	2	4	6
0	18.30	25.16	30.12
1.0	22.40	34.11	40.33
2.0	25.71	37.5	45.63
3.0	27.09	48.91	59.92
4.0	33.52	52.60	60.25
LSD ($P < 0.05$)	3.25	4.06	5.06

Table 2: Effect of different rates of cattle-dung application on the number of leaves per plant of Turmeric

Treatments (tons/ha)	Months After Planting (MAP)		
	2	4	6
0	4.42	7.23	10.20
1.0	5.60	15.70	17.34
2.0	5.77	17.50	20.09
3.0	6.01	22.17	24.06

4	6.20	24.61	27.13
LSD (P < 0.05)	4.15	4.41	4.75

Table 3: Effect of different rates of cattle dung application on the leaf area of turmeric plant

Treatment (tons/ha)	Months After Planting (MAP)		
	2	4	6
0	34.61	81.72	93.22
1.0	46.30	107.50	122.51
2.0	54.92	175.06	124.60
3.0	58.31	196.30	199.47
4.0	63.72	197.01	201.43
LSD (P < 0.05)	3.74	5.76	7.09

Table 4: Effect of different rates of cattle-dung application on the yield and yield components of turmeric plant

Treatment (tons/ha)	Number of Rhizomes/plant	Number of Tillers/Plant	Length of Tillers(cm)	Yield of Turmeric Rhizomes (t/ha)
0	2.24	2.43	17.20	6.75
1.0	3.52	3.91	19.90	11.46
2.0	4.36	5.26	21.30	14.13
3.0	5.22	5.71	23.71	18.25
4.0	5.75	5.92	25.41	18.44
LSD (< 0.05)	1.72	1.20	2.30	2.66

DISCUSSION

Increases in the tonnage of cow dung application, with corresponding increase in the plant height agree with the findings of Vanlauwe *et al.* (2001) who opined that soil structures and fertility are maintained or enhanced by the use of animal manure, compost, farm wastes and green manure as valuable sources of crop nutrients and organic matter that can improve soil biophysical conditions, thereby, making soils more productive and sustainable for food production.

The improved number of leaves and leaf area of turmeric of turmeric indicated the influence of cattle dung on them. The result agrees with Ikeh *et al.* (2012a) and Tremblay *et al.* (2011) who reported that livestock manure and droppings supplied some major nutrients (N, P, K, Ca, Mg, S), necessary for plant growth (plant height, number of leaves, leaf area, stem girth) and yield as well as micronutrients. Vanlauwe *et al.* (2001) and Udounang (2015) further reported beneficial effects of organic manure on the growth and yield of plants. Increases in cattle dung, increases yield components of turmeric. This affirms the reports of Udounang and Ndaeyo (2019) and Onunka (2005) that poultry manure is rich in nitrogen and thus plays an important role in the vegetative growth and yield of crops. This was also corroborated with the studies of Ferdous *et al.* (2018) and Effretuei (2020) that increase in number of leaves per plant was higher with attendant increase in yield due to increase in application of cattle dung.

Increasing the rates of application increased the yield per hectare of turmeric, while a decrease led to a subsequent decrease in yield. Olaniyi and Ojetayo (2010) emphasized the need to adopt the use of organic farming to increase farmer's yield and food production. According to Dauda *et al.* (2008), the use of organic manure as a substitute for inorganic fertilizer will help to achieve the global shift towards organic farming. Also, Ahmed *et al.* (2012) opined that organic manure is essential in improving soil productivity and crop production.

The significant response of turmeric to cattle dung rates could be due to low soil fertility status of the experimental site before planting. The result showed increase in cattle dung ratio with increase in growth and yield of the turmeric. The observation agrees with the findings of Nwanyieze *et al.* (2019); Udounang *et al.* (2022a) that high performance of crops under organic fertilizer application may be attributed to the amount of the organic manure that was used leading to the build-up of organic matter that improved the nutrient status of the soil (Ikeh *et al.*, 2012b; Udounang *et al.*, 2022b) with general positive influence on soil nitrogen for crop production. Lal (2016) and Umoh *et al.*, (2022) reported that soil organic matter contents affects crop yield through its role in enhancing and sustaining soil quality and soil health. This affirms the role of the cattle dung application in the soil and hence the attendant effect on turmeric production. According to Ibn (2015) turmeric plants produced more secondary rhizomes when cow dung manure was applied as compared to any other fertilizer. The addition of organic fertilizer improves the soil texture and structure, as well as the binding power and drainage. The use of organic manure lengthens the time that nitrogen is available in the soil aggregate; long-term nutrient availability is important to a long-lived plant such as Java turmeric.

CONCLUSION

Based on the study findings, the application of 4.0 tonnes/ha rate produced significantly higher rhizome yields, followed by 3.0 tonnes/ha. These two rates are therefore, recommended to farmers for higher yield of turmeric in Obio Akpa, Akwa Ibom State.

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EFFECT OF INTRA-ROW SPACING AND POTASSIUM APPLICATION ON PLANT HEIGHT AND TOTAL TUBER YIELD OF POTATO (*SOLANUM TUBEROSUM* L.) VARIETIES IN THE NORTHERN GUINEA SAVANNA ZONE-NIGERIA

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ABSTRACT
A feld experiment was conducted during 2016 and 2017 wet seasons at the experimental Farm of National Root Crops Research Institute, Umudike, under the Potato Program at Kuru, and at Teaching and Experimental Farm, Plateau State University, Bokkos ,Jos-Plateau. The experiment studied growth and yield of potato (Solanum tuberosum L.) varieties as influenced by intra–row spacing and potassium application. The experimental design was a Randomized Complete Block Design, laid out as a factorial and replicated three times The treatments consisted of three potato varieties (Zafira, Caruso and Connect), three intra–row spacings (20, 30 and 40 cm) and three potassium (K) fertilizer rates (0, 40 and 60 kg k_2O ha^{-1}). Potassium and intra-row spacing were collectively the main plots, while variety was the sub plots. The results revealed that application of 60 kg K_2O ha^{-1} gave significantly highest ($p<0.05$) higher growth and yield parameters. The result also, indicated that Connect, gave significantly highest ($p<0.05$) higher height and total tuber yield than all the other varieties used, At Bokkos, plant height had highest ($p<0.05$) value at 30 cm intra – row spacing while at Kuru, it was at 20cm intra - row spacing. Plant height and total tuber yield t ha^{-1} gave highest values ($p<0.05$) at 60 kg k_2O ha^{-1}. Variety Connect planted at 40cm intra–row spacing and treated with 60 kg K_2O ha^{-1} produced the tallest ($p<0.05$) plant and highest yield at both locations. Therefore, connect could be adopted for production in the northern Guinea Savana of Nigeria.
Keywords: *Potato, potassium Intra-row Spacing*

INTRODUCTION
Potato (*Solanum tuberosum* L.) belongs to the family *Solanaceae.* The word potato may refer either to the plant itself or the edible tuber (FAO, 2021). Plant nutrition is important especially on the Jos Plateau, where continuous cropping and mining has greatly depleted the soil of the major native nutrients such as N, P and K (Okonkwo *et al.*, 1995). Potato requires a deep well – drained sandy or silt loamy soils with a soil pH between 5.5 to 6.5 with low temperatures (15–20^0). The ideal soil temperature for planting is 13 – 16^0 C and 21^o C for growth. Growth is retarded at temperatures below 7^o C or above 28^o C. Potato requires 400 to 500 mm of rain per annum, spread across five months depending on variety, weather and soil type (AHDB, 2020).

In Nigeria, especially on the Jos plateau, potato is a crop that is harvested early in the wet seasons and tremendously at combating hunger and poverty in homes of resource poor farmers. The problem of spacing is common on farmers field resulting in fewer stands per unit area or overcrowding resulting in competition and subsequently, poor yields. Okonkwo *et al*. (1995), reported that 30 cm intra-row spacing was more appropriate for rain fed ware potato production, whereas, generally, farmers use wider spacings (50–60 cm), and in most cases, grow the crop as an intercrop with maize. Therefore, it has become imperative study more suitable intra-row spacing that will enhance potato growth, development and tuber yield per unit area. Reports have also indicated that low potato yields by on the Jos Plateau attributed to their inability to adequately fertilize, especially potassium, due to scarcity and high cost. It is therefore the objectives of this study to study growth and yield of potato varieties in response to various intra–row spacing and rates of potassium fertilizer.

MATERIALS AND METHODS
A field experiment was conducted during the wet seasons of 2016 and 2017 at Kuru at Plateau State University Teaching and Rsearch, Bokkos, Jos-Plateau, in the Northern Guinea Savanna Zone of Nigeria. Ten soil samples within the experimental sites were randomly collected each year, at a depth of 0–30 cm using soil auger. The soil

samples were bulked into a composite sample air dried, ground into powder and sieved using 2 mm mesh sieve and analyzed for selected physical and chemical properties.

The experiment studied growth and yield of potato (*Solanum tuberosum* L.) varieties as influenced by intra–row spacing and potassium application. The experimental design was a Randomized Complete Block Design, laid out as a in a factorial and replicated three times The treatments consisted of three potato varieties (*Zafira*, *Caruso* and *Connect*), three intra–row spacings (20, 30 and 40 cm) and three potassium (K) fertilizer rates (0, 40 and 60 kg k_2O ha^{-1}). Potassium and intra-row spacing were collectively the main plots, while variety was the sub plots. The results revealed that application of 60 kg K_2O ha^{-1} gave significantly highest ($p<0.05$) higher growth and yield parameters... Weed control was done at planting using pre-emergence herbicide (Alachlor at 1.92 kg a.i ha^{-1} and Atrazine powder at the rate of 4 kg a.i ha^{-1}), using CP-15 Knapsack sprayer at a pressure of 2.1 kg cm^2 and by manual hoe weeding at

Table 1: Effect of intra-row spacing and potassium fertilizer on plant height of potato varieties in 2016 and2017 cropping seasons at Bokkos and Kuru

	Plant height at 9 WAP (cm)					
	Bokkos			Kuru		
Treatments	**2016**	**2017**	**Combined**	**2016**	**2017**	**Combined**
Varieties (V)						
Zafira	52.52c	51.64c	52.08c	55.06c	53.71c	54.39c
Caruso	57.74b	56.96b	57.35b	60.60b	56.57b	58.58b
Connect	63.78a	61.60a	62.69a	61.59a	58.77a	60.18a
SE±	0.452	0.562	0.361	0.300	0.609	0.339
Spacings (S) cm						
20	58.14ab	57.10	57.62a	59.72a	55.50	57.61ab
30	58.94a	57.22	58.08a	59.97a	57.29	58.63a
40	56.97b	55.87	56.42b	57.57b	56.26	56.92b
SE±	0.568	0.493	0.365	0.261	0.779	0.399
Potassium (K) kg ha^{-1}						
0	55.31c	54.62b	54.96c	57.33c	54.70b	56.01c
40	58.10b	57.10a	57.60b	58.88b	55.56b	57.22b
60	60.64a	58.47a	59.55a	61.05a	58.80a	59.92a
SE±	0.568	0.493	0.365	0.261	0.779	0.399
Interaction						
K x S	NS	NS	NS	NS	NS	NS
K x V	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS
K x S x V	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group and column are not significantly ($P<0.05$) different using DMRT. NS=NOT Significant ($P<0.05$), WAP=Week after Planting

Table 2: Effect of intra-row spacing and potassium fertilizer on total tuber yield of potato varieties in 2016 and 2017 wet seasons at Bokkos and Kuru

	Total tuber yield (t ha^{-1})					
	Bokkos			Kuru		
Treatments	**2016**	**2017**	**Combined**	**2016**	**2017**	**Combined**
Varieties (V)						
Zafira	7.73c	4.70b	6.21b	7.70b	5.71b	6.71b
Caruso	9.61b	4.62b	7.11b	8.48b	6.00b	7.24b
Connect	31.39a	22.08a	26.73a	29.46a	24.85a	27.15a
SE±	0.591	0.407	0.359	0.511	0.587	0.536
Spacings (S) cm						
20	11.29c	6.63c	8.96c	10.95c	8.12c	9.54c
30	16.88b	9.98b	13.43b	15.37b	12.63b	14.00b
40	20.56a	14.80a	17.68a	19.32a	15.80a	17.56a
SE±	0.624	0.337	0.354	0.483	0.490	0.334
Potassium (K) kg ha^{-1}						
0	4.18c	4.70b	4.45c	3.92c	3.02c	3.47c
40	18.98b	21.62a	20.30b	17.42b	24.15a	20.78b
60	25.57a	22.08a	23.83a	24.30a	23.59a	23.95a
SE±	0.624	0.407	0.354	0.483	0.490	0.334

Interaction						
K x S	NS	NS	NS	NS	NS	NS
K x V	**	*	NS	**	NS	NS
S x V	NS	NS	NS	NS	NS	NS
K x S x V	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group and column are not significantly ($P<0.05$) different using DMRT. NS=NOT Significant ($P<0.05$), * = Significant ($P < 0.05$).

4 and 8 weeks after planting (WAP). Earthen up was done at 9 WAP. Pest and disease were controlled by application of Ridomil at the rate of 2.5 g and F–Force (mancozeb 2.0 g a.iha^{-1}), applied bi-weekly from 2 WAP, to prevent fungal diseases attack. Bacterial wilt (*Rhalstonia Solanecearum*) was controlled by rogueing from 3 WAP to harvest. Potato tuber moth and rodents were controlled using Pestox 2.0g a.i $ha^{-1}$and rodenticide (Phostocin) at 1.0g/ per plot respectively at 4 WAP. Harvesting was done at 12 WAP when 95 % of the leaves turned yellow accompanied by senescence,. This was done carefully by lifting the stands with garden fork. Thereafter the tubers were hand-picked and weighed immediately using a portable weighing balance of 120 kg capacityThe data collected were subjected to analysis of variance (ANOVA) using a General Linear Model in statistical Analysis System (SAS) Package. Significant means were sperarted using Duncan's Multiple Range Test, (DMRT) at 5 % level of probability.

RESULTS AND DISCUSSION

Table 1 shows effects of intra-row spacing and potassium fertilizer on plant height of potato varieties at 9 WAP at Bokkos and Kuru during the 2016 and 2017 cropping seasons. At both locations, variety Connect produced significantly ($p<0.05$) taller plants, followed by Caruso, while Zafira produced the shorter plants ($p<0.05$). This could be attributed to varietal response to environmental factors and treatments. Connect was assumed to be more responsive than other varieties. This agrees with the reports of Abong *et al.*, (2013) that potato varieties responded significantly to intra-row spacing and fertilizer application through plant height. The superiority of Connect and Caruso over Zafira in terms showed to morphological superiority hence, faster growth.

At Bokkos, in 2016, 2017 and at Kuru in 2016, height of potato (20 and 30 cm intra–row spacing) were statistically ($p<0.05$) similar, buT taller (40 cm). In 2017, at Kuru, intra - row spacing (30 and 40 cm), were similar ($p<0.05$). A similar trend was observed at Bokkos and Kuru, in 2016, where increased K rates (0 to 40 and 60 kg K ha^{-1} correspondingly increased plant height, This trend was also observed in 2017 at Kuru and Bokkos, for 0 and 40 kg K ha^{-1} at 60 kg K ha^{-1}. but at 40 and 60 kg K ha^{-1}.

Table 2 shows effect of intra-row spacing and potassium fertilizer on total tuber yield potato varieties during the 2016 and 2017 wet seasons and the combined mean of two at Bokkos and Kuru. In 2016, at Bokkos Connect produced the highest ($p<0.05$), total tuber yield followed by Caruso, while Zafira had the least ($p<0.05$), total tuber yield t ha^{-1}. However, in 2017, combined data and at Kuru in the two years of evaluation, Zafira and Caruso were ($p<0.05$), but lower in total tuber yield t ha^{-1} than Connect. Increasing intra-row spacing from 20 to 30 and further to 40 cm at both locations correspondingly increased total tuber yield t ha^{-1}. This trend was still observed at Bokkos except in 2017 at at Kuru, where increasing K rates from 0 to 40 and further to 60kg K_2O ha^{-1} correspondingly increased total tuber yield. Only the interaction of K fertilizer rates and variety on total tuber yield t ha^{-1} in 2016 at Bokkos and Kuru was significant ($p<0.05$). Larger LAI values resulted in greater assimilate production and hence higher DM production and accumulation and subsequently total tuber yield.

CONCLUSION

Base on the findings of this study, variety Connect can be adopted for the study locations in view of its consistencies crop growth and yield. The use of 30 cm intra-raw spacing for potato production for Zafira and Caruso is irecommended for the two locations, while 40 cm intra–raw spacing is recommended for Connect. Application of 60 kg K_2O ha^{-1} is recommended for potato production at Bokkos and Kuru

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EFFECT OF MULCH MATERIALS ON WEED DENSITY, GROWTH AND YIELD OF OKRA (*ABELMOSCHUS ESCULENTUS*) AT ISHIAGU SOUTHEAST-NIGERIA IN THE DRY SEASON

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ABSTRACT
An experiment was conducted in the dry season to determine the effect of different mulching materials on weed density, growth and yield of Okra. The study was conducted at the Teaching and Research Farm of Federal College of Agriculture, Ishiagu. The experimental design used was Randomized Complete Block Design (RCBD), consisting of five (5) treatments (rice husk dust, white polythene, saw dust, black polythene mulch and control), and replicated three times. Parameters evaluated were plant height, number of leaves, number of pods, weight of pods at harvest, and density of weeds respectively. The results indicated significant effect (p<0.05) of treatments on plant height at 6 and 9 weeks after planting. Also, on weed density at 4 and 8 weeks of planting. The effect of mulch materials on yield was significant (p<0.05) with rice husk dust treatment, with effect on number and weight of harvested pods. Polythene mulch treatment recorded a significant (p<0.05) reduction on weed infestation. Polythene mulch is therefore, recommended for use in dry season for okra production.
Keywords: *Okra, mulch materials, growth and yield.*

INTRODUCTION
Mulching is an effective method of manipulating a crop's growing environment to increase yield and improve product quality through effective control of weed growth, ameliorating soil temperature, conserving soil moisture, reducing soil erosion, improving soil structure and enhancing organic matter content (Awodoyin and Ogunyemi, 2005). Mulching cropped soils favorably influences the soil moisture regime by reducing evaporation from the soil, reducing erosion and leaching, minimizing weed infestation and increasing the yield of crop by at least 50 % (Awodoyin and Ogunyemi, 2005).
Soil moisture conservation under dry season crop production requires appropriate mulching practices to conserve adequate soil moisture for enhanced plant growth and optimum yield (Cornelis, *et al.*, 2013). Materials that can be used for mulching includes sawdust, polythene, grasses, paper. The use of sawdust, polythene and straw mulches for dry season vegetables production is reported to decrease soil temperature, conserve moisture and with positive roles in water conservation (Dalorima *et al.*, 2014).
Okra (*Abelmoschus esculentus* L. Moench) is a popular vegetable in tropical and sub-tropical countries of the world, generally grown for its pods (Daniel-Kalko, 1982). According to Dalorima *et al.* (2014), okra is grown in both the wet and dry seasons, but attracts higher profit during the dry season when the demand is often higher than supplies. Despite its nutritional and commercial values, this crop is still produced at the subsistence level because of inadequate soil moisture in the dry season (Sanni and Eleduma, 2014). Reports indicate that using the wrong mulch material can lead to crop failure (Dalorima *et al.*, 2014). The objective of this work was therefore, to evaluate the effect of mulch materials on Okra production in the dry season.

MATERIALS AND METHOD
The study was carried out at the Teaching and Research Farm of Federal College of Agriculture, Ishiagu-Ebonyi State, Nigeria, during the 2022 season.
The experimental designed was Randomized Complete Block Design (RCBD) with five (5) treatments replicated three times. Rice husk dust 10 t/ha, saw dust 10 t/ha, black polythene 10,000 m^2/ha, white polythene 10,000 m^2/ha and control (no mulchl). The black and white polythene mulch materials were perforated and placed at recommended field planting distance, and the okra seeds were planted. Saw dust and rice husks dust was evenly spread on the beds according. Weeding was done manually at four (4) weeks intervals after planting. The weeds

were first identified and collected in each plot and weighed to determine treatments with higher density of weeds. Data obtained were plant height, number of leaves, number and weight of pods at harvest. Data obtained were analyzed using analysis of variance (ANOVA)) at 5 % level of probability Obi, (2002).

RESULTS

The result obtained indicated significant ($p<0.05$) changes in plant height at 6 and 9 WAP (Table 1). Black Polythene recorded the highest plant height (22.8 cm and 45.3 cm), while control had the lowest values (4.03 and 10.01 cm). Similarly, the number of leaves (Table 1), were significantly ($p<0.05$), affected at 6 and 9 WAP, with black Polythene bags recording the highest values of (9 and 12 cm), followed by white Polythene (8 and 10 cm), while the least was recorded in control (6 and 7 cm) respectively.

The number of pods differed significantly ($p<0.05$), among treatments ranging from 146 to 238 as obtained in control and rice husk dust (Table 2). Weight of pods, (5.60 t/ha) were significantly higher ($p<0.05$), in plots mulched with rice husk dust though, statistically similar ($p<0.05$), with plots mulched with black polythene (5.06t/ha),

On weed density, result (Table 2) revealed that black Polythene mulch recorded the lowest density of weed (0.2kg and 0.1kg), ($p<0.05$), followed by white Polythene (0.3kg and 0.3kg) while control recorded the highest density of weeds (1.6 kg and 1.8 kg) at 4 and 8 weeks after planting.

Table 1: The effect of different treatments on plant height (cm) and Number of leaves

Treatments	**Plant Height (cm)**			**Number of leaves**		
	3 WAP	**6 WAP**	**9 WAP**	**3 WAP**	**6 WAP**	**9 WAP**
Black Polythene	5.33	22.8	45.3	5	9	12
White Polythene	5.13	20.8	44.7	5	8	10
Rice husk dust	5.04	20.2	44.5	5	8	9
Saw dust	4.43	20.10	42.4	4	6	9
Control	4.03	10.01	20.5	3	6	7
LSD $_{(0.05)}$	NS	2.1	2.8	NS	2.1	2.8

Table 2: The effect of different treatments on yield and weed density (kg)

Treatments	**Yield**		**Weed density (kg)**	
	No of Pods	**Weight of Pods t/ha**	**4 WAP**	**8 WAP**
Black Polythene	212	5.06	0.2	0.1
White Polythene	202	5.04	0.3	0.3
Rice husk dust	238	5.60	1.3	1.1
Saw dust	200	5.10	1.2	1.1
Control	146	2.45	1.6	1.8
LSD $_{(0.05)}$	15.6	0.31	0.02	0.04

DISCUSSION

The higher growth of recorded under mulching may be attributed to enhanced growth of okra plants due to better moisture conservation and suppressed weed infestation. This agrees Hudu *et al.* (2002) who reported superiority of mulched plants over those unmulched. Also, Nwite *et al.* (2008), reported that rice husk dust can be used for the improvement of nutrient status of soils as it contains elements like Ca, Mg, S, Na, Cu, Mn, Fe, K, P, N which are necessary for plant and for soil improvement. The observed reduction in weeds infestation in polythene mulch and higher in pod yield, is in line with Li and Xiao, (1992) using plastic mulch is assumed to be because of better soil moisture retention and reduced soil temperature, and consequently, reduced weed infestation, hence, lesser competition for soil nutrients and water.

CONCLUSION

The use of mulch has been shown to be effective especially in dry season farming. The use of rice husk dust as mulch has proven to be the best of the trial and is recommended to increase okra yield.

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DETERMINATION OF DISTRIBUTION PATTERN OF FAN AND CONE NOZZLES USING DISCHARGE RATE AND SPRAY VOLUME

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ABSTRACT
A laboratory Patternator was used to determine the discharge rate and the spray volume distribution pattern of fan and cone nozzle. The test was conducted at various nozzle heights above the patternator and various operating pressure. Discharge rate test between fan and cone nozzle was statistically not significant at 5% or 1% level of significance when comparing the difference between the two types of nozzles. The best height of even distribution for fan nozzle was attained at 10cm height above target while for cone nozzle was attained at 40cm. The comparison between the two types of nozzle shows that the difference was not significant statistically at 5% or 1% level of significance.
Keywords: *Fan, Nozzle, Pesticides, Spatternray Discharge rate.*

INTRODUCTION
Crop yield is reduced mainly due to attack of pests, diseases and weeds. Chemicals control is the popular method adopted for controlling most insects, fungi, weeds and diseases. They are applied in varying amounts, depending upon the type and concentration of active ingredients. At present in Nigeria the farmers are mostly using hydraulic energy sprayers in their fields (Bello, 2012). Hydraulic energy sprayers are sprayers that use hydraulic pressure energy to break spray liquid into droplets of a wide range of sizes. In the hydraulic sprayer, a pump supplies energy that carries spray material to the target. Understanding how to use these sprayers is essential for the successful application of agricultural chemicals, especially selective post emergence herbicides. In order to successfully use herbicides, their application must be accurate and uniform.

Nozzles spray tips, multiple nozzle booms, pressure regulation and sprayer calibrations are the essential components of the spray- application technology. Spray tips are the most important nozzles component. It determines the flow and distribution of the spray (Miller and Bellinder, 2001). The proper selection of a nozzle type and size is essential for proper pesticides application. Nozzle breaks the liquid into droplets in the proper direction. This publication covers the comparison of flat-fan and hollow cone nozzles in terms of their discharge rate and spray volume distribution patterns. The finding of the research study presented in this paper could be used in the selection of appropriate nozzle for spraying pesticides in field crops.

MATERIALS AND METHODS
Materials and Equipment: The materials and equipment's listed below were used for the experiments;

v. Stop watch for time recording
vi. Glysophate post emergence herbicides as test fluids for the experiment. It is chosen because of its harmlessness, low cost and readily available.
vii. Measuring Cylinder
viii. A hygrometer consisting of wet and dry bulb thermometers.
ix. A universal laboratory

Methodology: The following outlined procedures were used for carrying out the laboratory test determination of spray volume distribution pattern test and discharge rate test.

Discharge rate test: Each nozzle was mounted on the patternator and discharge at the same time interval was collected in three replicates of operating pressure of 15,30, and 40psi. The discharge rate for each and total discharge rate were determined for the nozzles. Operating pressures and height of nozzle above the target were recorded. The discharge rate was determined using the expression given below (Mathews, 1992);

V = $\underline{Q_{av}}$ ($^{L}/_{min}$)…………………. (1)

T_{av}

Where, V = discharge rate (1/min)

Q_{av} = Average discharge (I)

T_{av} = Average time for discharge (min)

Spray Volume distribution pattern test: The main objective of this test was to determine the degree of uniformity of spray chemical emitting from the sprayer. The test was carried out on a patternator of size 115cm x 115cm. The patternator has 22 continuous triangular grooves at equal spacing of 5mm, a rack carrying spray-collecting calibrated cylinder tubes, which is mounted below the collecting end points of the grooves. Considering the size of the patternator, one nozzle each was mounted and corresponding spray volume distribution patterns were determined. The spray volume distribution test was done for different operating pressures for the two types of nozzles (Flat fan and hollow cone nozzles). The sprayer was operated for 60 seconds (1min) in each situation to be able to obtain a measurable amount of spray from the collecting tube and this was replicated three times. Statistical method of coefficient of variation of the spray collected along the swath was used to analyse the results to compare the variability and the uniformity degree of the spray volume distributed across the swaths of various heights (Buba *et al,* 2013 and Bitrus, 1985). While t-test of significance at 5% and 1% level of significance was used to determine the comparison between the types of nozzles used.

Plate 1: Patternator used in determining the spray volume distribution pattern of the sprayer nozzle at various height and pressure.

RESULTS AND DISCUSSION

Nozzle Discharge Rate (m1/min): The effects of operating pressure and heights of nozzles above the target or patternator on nozzle discharge rate for both fan and cone nozzles are presented in Tables 1 and 2 respectively. It also shows that for a given combination of variables, the discharge rate change appreciably with different operating pressure used.

Table 1: Total Average Discharge for Fan Nozzle Per Unit Time

Nozzle Height (cm)	**Total Discharge Rate (1/min) At Different Operating Pressure (psi)**		
	15	30	45
10	5.14	7.95	9.15
20	5.55	8.8	10.3
30	7.46	10.95	13.22
40	2.86	5.8	10.62

Table 2: Total Average Discharge for Cone Nozzle Per Unit Time

Nozzle Height (cm)	Total Discharge Rate (1/min) At Different Operating Pressure (psi)		
	15	30	45
10	6.42	9.02	10.73
20	8.31	9.98	9.97
30	6.54	8.65	10.7
40	6.88	9.22	9.75

These data were subject to t-test of significance that compared the two types of nozzle if there was any significance difference. From the results of the t-test, the calculated t value (1.12) was lesser than the table t value at degree of freedom equal to 11, at 5% level of significance (2.20) and even at 1% level of significance (3.11). This can be said that the difference between the two types of nozzles that is fan and cone nozzle was statistically not significant, hence that is negligible.

Nozzle spray volume distribution pattern test: The spray volume distribution pattern was carefully studied in the laboratory in order to determine the height of best even distribution of the spray chemical. Uniformity of spray along the swath was determined by coefficient of variation methods. The results are presented in Tables 3 and 4 for both fan and cone nozzles respectively. Tables 3 and 4 show the coefficients of variation results for various nozzles heights (cm) and operating pressure (psi).

Table 3: Coefficient of Variation (%) for fan Nozzles Pattern Obtained from Different Nozzle Heights at Various Operating Pressures.

Nozzle Height (cm)	Total Discharge Rate (1/min) At Different Operating Pressure (psi)		
	15	30	45
10	63.2	24.0	8.6
20	41.8	35.8	47.2
30	66.8	50.4	63.0
40	38.3	49.2	45.6

Table 4: Coefficient of Variation (%) for Cone Nozzles Pattern Obtained from Different Nozzle Heights at Various Operating Pressures.

Nozzle Height (cm)	Total Discharge Rate (1/min) At Different Operating Pressure (psi)		
	15	30	45
10	55.5	58.3	51.6
20	48.9	54.7	54.2
30	55.3	55.2	47.1
40	39.9	38.5	48.9

From Table 3, the height of best even distribution was attained at nozzle height of 10cm while from Table 4, the height of best even distribution was attained at nozzle height of 40cm. Further analysis using t-test of significance that compared the two types of nozzles. The t-test showed that the calculated t value (1.17) was lesser that the table t value at degree of freedom equal to 11, 5% level of significance (2.20) and even at 1% level of significance (3.11). This can be said that the different between the two types of nozzle that is fan nozzle and cone nozzle was statistically not significant that is, it is negligible.

CONCLUSION

The study concluded that both fan and cone nozzle were tested for discharge rate and spray volume distribution pattern test. Discharge rate test between fan and cone nozzle showed that cone nozzle has higher discharge rate than fan nozzle, but further analysis using t-test of significance gave that the different between two types of nozzles was statistically not significant. Spray distribution pattern test was analysed using coefficient of variation method to get the height of best even distribution, which gave the best height for fan nozzle as 10cm and the best height for cone nozzle is 40cm. Further analysis using t-test of significant, compared the coefficient of variation values for both nozzle and obtained that the different between two types of nozzles was statistically not significancee.Showing that any of the nozzles can be recommended depending on the availability.

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RESTORING SOIL FERTILITY STATUS AND COCOYAM YIELD IMPROVEMENT THROUGH DIFFERENT SOIL AMENDMENTS IN ISHIAGU, EBONYI STATE, NIGERIA

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ABSTRACT
The study was conducted in the lowland research farm of the Federal College of Agriculture, Ishiagu, Ebonyi State, during the dry season cropping period (February to April) of 2020 and 2021, to evaluate the effects of different soil amendment sources on selected fertility indices and cocoyam yield. The lowland field is usually used for rain-fed rice production during the rainy season. Randomized complete block design (RCBD) was used to study these soil amendments. The soil amendments include; poultry dropping (PD) at 10t/ha, NPK 15:15:15 fertilizer (NPK) at 300 kg/ha, rice husk dust (RHD) at 10 t/ha, PD at 5t/ha + RHD at 5 t/ha, NPK at 150 kg/ha + RHD at 5t/ha and control, replicated three times. Soil chemical properties evaluated were soil pH, organic carbon, total nitrogen (TN), available phosphorous and cation exchange capacity. The plant parameters studied were cocoyam corms and cormel yield. Results showed that PD + RHD amendment recorded significantly ($p < 0.05$) higher (5.97) pH than other amended plots, whereas soil organic carbon was significantly improved best (13.77 g/kg and 13.80 g/kg) by RHD treated plots in both years. It was obtained that NPK + RHD significantly increased TN in the 1st year as against PD + RHD in the 2nd year. Yield was also improved by the amendment combinations. It is therefore concluded that the complementary use of NPK and PD; and integration of poultry dropping and rice husk dust (PD + RHD) were better soil fertility management strategies for cocoyam production in Southeastern Nigeria.
Keywords: *Cocoyam, corms, cormels, soil amendments, chemical properties, integrated nutrient management*

INTRODUCTION
Cocoyam (*Colocasia esculenta*) is a major source of carbohydrates in Nigeria and a tropical food crop with high potential because of the high yield of the roots (corms) and foliage. The corms and cormels are eaten in the same way as yam (*Dioscorea spp*) and sweet potato (*Ipomoea batatas*), boiled, fried, baked and roasted (Uwah *et al.*, 2011). In spite of the crop's nutritional qualities and industrial uses, its yield in Nigeria (5143kg/ha) is still very low compared with yields in developed countries (Nwite *et al.*, 2016a). The very low yield may be attributed to poor production practices such as inappropriate use of fertilizers and other agrochemicals. In Nigeria, Cocoyam production practices are still carried out by poor rural women farmers who cannot afford the high cost of these fertilizers (Fadina and Ogunyemi, 2002; Apantaku 2000).
The soils on which this cocoyam grows are referred to as an integral component of Agriculture and serve as a medium for numerous ecological, chemical and physical processes. Overburdening of this soil as a natural resource base of agricultural production has always been an issue due to its widely varied applications in the maintenance of human life activities (Omatayo and Chukwuka, 2009). The need thus to effectively manage soil resources in order to achieve optimum productivity of soils is obvious.
In Nigeria and other tropical countries, it is the utmost interest of most farmers to produce sustainable high crop yield. However, according to Ayeni *et al.* (2009), a decrease in soil fertility after a few years of cropping is always a major limitation of these tropical soils. The use of chemical (inorganic) fertilizer in crop production has not been sustainable due to its high cost and scarcity, increased soil acidity and soil bulk density, low water infiltration rate and nutrient imbalance (Nwite *et al.*, 2016b; Nottidge and Ojeniyi, 2005).
However, the complementary use of organic and inorganic fertilizers has been reported to be a good soil fertility management strategy for crop production. Single-use of either organic or inorganic fertilizers in recent years has not really met the expected impact in boosting crop yield to cope with the geometric demand for food in Nigeria (Nwite *et al.*, 2016). The physical, chemical and biological fertility of most Nigerian soils like other tropical soils

have fallen beyond the level considered suitable for efficient and profitable crop production due to loss in nutrients. The soils have to be amended and managed in a special manner to be cultivated profitably (Modal and Sen, 2005; Ogbonna and Nweze, 2012; Udoh *et al*., 2005).

The study therefore aims at investigating the effects of different soil amendment sources on selected soil chemical properties and cocoyam yield improvements in Southeastern Nigeria.

MATERIALS AND METHOD

Description of Experimental Site

The study was carried out in the research farm of the Federal College of Agriculture, Ishiagu, during the 2020 and 2021 cropping seasons. The study area lies within latitude 05^0 56'N and longitude 07^0 41'E in the derived savannah zone of Southeastern Nigeria. The area has a mean annual temperature of about 30^0C and rainfall of 1350mm. Geologically, the area is underlain by sedimentary rock derived from successive deposits of the cretaceous and tertiary period and lies within the Asu River Group (Lekwa *et al*., 1995; Nwite *et al.*, 2008).

Experimental Design/ layout

A randomized complete block design (RCBD) was employed for the study. There were six soil amendment sources used, replicated 3 times. These include;

- Poultry droppings sole at 10t/ha (PD)
- NPK 15:15:15 fertilizer at 300kg/ha
- Rice husk dust sole at 10t/ha (RHD)
- NPK at 150kg + Rice husk dust at 5t/ha
- poultry droppings at 5t/ha + Rice husk dust at 5t/ha
- Control

The land was tilled into suitable seed beds (beds preparation) representing plots with a native hoe, measuring 2 m x 2 m with a plant spacing of 50 cm by 50 cm at a planting rate of one (1) cormel per hole. The poultry dropping and rice husk dust were applied a week before planting while the NPK 15.15.15 was applied at 2 weeks after planting.

Soil Sampling and Laboratory analysis

At the commencement of the experiment, a composite soil sample from random points was collected from the site using a soil auger at 0 - 20cm depth. At the end of each harvest, another set of auger samples was collected from all the identified sampling points on each of the plots from the top (0-20cm) soil depth for laboratory analysis.

The auger topsoil samples were air-dried and sieved through a 2.00mm sieve. Soil fractions less than 2.00mm from individual samples were then analyzed using the following methods.

Particle size analysis: The particle size distribution of the samples was determined by the hydrometer method (Gee and Bauder 1986). Soil pH was measured in a 1:2.5 soil: 0.1 M KCl suspensions (McLean, 1982). The soil organic carbon (OC) was determined by the Walkley and Black method as described by Nelson and Sommers (1996). Total nitrogen was determined by a semi-micro Kjeldahl digestion method using sulphuric acid and $CuSO_4$ and Na_2SO_4 catalyst mixture (Bremner and Mulvancy, 1982). CEC was determined by the method described by Thomas (1982), while the available phosphorous was determined by the Bray 2 method (Bray and Kurtz, 1945).

Data Analysis

Data collected were analyzed using GENSTAT 3 7.2 Edition. Significant treatment means were separated and compared using Fisher's least significant difference (F-LSD) and all inferences were made at 5% levels of probability according to Obi (2002).

RESULTS AND DISCUSSION

Selected initial physical and chemical properties of the soil

The chemical properties of the studied soil before the application of amendments are shown in Table 1. The soil has percent fine sand as 460 g/kg, 290 g/kg silt and 160 g/kg clay, while the coarse sand has 90 g/kg. The soil is acidic with a pH of 4.5. The organic carbon and total nitrogen of the soil were 1.197 g/Kg and 0.140 g/kg, respectively. The analysis indicated that the studied soil was low in cation exchange capacity and available phosphorous.

Table1 Selected initial physical and chemical properties of the studied soil (0-20cm) depth.

Soil properties	Value
Clay (g/kg)	160
Silt (g/kg)	290
Fine sand (g/kg)	460
Coarse sand (g/kg)	90
pH (H_2O)	4.5
Organic carbon (g/kg)	1.197
Total nitrogen (g/kg)	0.140
Exchangeable base (cmol/Kg)	
Sodium (Na^+)	0.08

Potassium (K^+)	0.154
Calcium (Ca_2^+)	3.20
Magnesium (Mg^{2+})	1.60
Cation exchange capacity (cmol/kg)	14.60
Base saturation (%)	36.58
Exchangeable acidity (cmol/kg)	1.40
Available phosphorus (mg/kg)	2.80

Effect of different soil amendment sources on fertility indices (Soil pH, organic carbon, total nitrogen, available phosphorous and cation exchange capacity)

The results (Table 2) showed that there were significant ($p < 0.05$) variations in the soil pH due to the soil amendments used for the two years of study. It was obtained that the highest pH improvement (4.93) was recorded in poultry dropping amended plots within the 1st year, while in 2nd year, plots with integration of poultry dropping (PD) and rice husk dusk (RHD) (PD + RHD) gave the highest significant increase (5.97) on the soil pH. Generally, it was obtained that the mixtures of the amendment sources did improve the soil pH higher in the 2nd year more than their sole sources. These results agree with Nwite *et al.* (2016a) who reported that integration of mineral fertilizer with organic fertilizer or two organic sources reduces the impact of acidity, hence increasing soil pH.

Table 2 reveals that soil organic carbon was significantly ($p < 0.05$) increased in both years of study with the best significant ($p < 0.05$) increase (13.77 g/kg and 13.80 g/kg), respectively from plots amended with sole rice husk dust (RHD). This implies that rice husk dust contains very contents of carbon as an amendment which was transmitted into the soil when applied.

Total nitrogen did not vary significantly ($p < 0.05$) in the 1st year but showed significant ($p < 0.05$) variation in the 2nd year of study. The results (Table 2) indicated that the most significant ($p < 0.05$) improvement of 2.253 g/kg was obtained from PD + RHD treated plots. The study generally indicated that organically amended plots and their integrated forms including the mixture of NPK + RHD increased the soil total nitrogen higher than the sole NPK application. The results showed that all amended plots except the NPK-treated plots significantly ($p < 0.05$) improved the total nitrogen higher than the control.

Available phosphorous varied significantly ($p < 0.05$) within the two years of study due to the amendments employed. It was recorded that plots treated with NPK in the 1st year significantly ($p < 0.05$) improved the available phosphorous higher than treated plots, while in the 2nd year, PD and PD + RHD amended plots which statistically are the same in values (18.26 mg/kg and 15.87 mg/kg), respectively, increased the soil parameter higher than other treated plots including the control.

The results (Table 2) indicated that cation exchange capacity (CEC) varied statistically in both years of study. It was obtained that in the 1st and 2nd year, PD + RHD amended plots improved the soil CEC significantly ($p < 0.05$) higher (27.04 Cmol/kg and 29.18 Cmol/kg), respectively, than other amended plots including the control. Generally, all the treated plots improved the soil CEC statistically more than the control plots. This finding is in conformity with the submissions of Nwite *et al.* (2016b) and Hulugalle and Maurya (1991) who reported a higher increase in soil CEC and other soil nutrients on treated soils compared to the untreated ones.

Table 2 Effect of different soil amendment sources on fertility indices (Soil pH, organic carbon, total nitrogen, available phosphorous and cation exchange capacity)

Soil amendments	Soil pH		Soil organic carbon (g/kg)		Total nitrogen (g/kg)		Available phosphorous (Mg/kg)		Cation exchange capacity (Cmol/kg)	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year2
CT	4.30	4.20	9.15	11.06	1.260	1.073	5.44	6.44	16.28	16.59
NPK	4.50	4.23	9.71	8.75	1.220	1.233	17.50	14.13	22.95	19.06
PD	4.93	5.20	11.62	11.92	1.380	2.187	9.43	18.26	20.93	28.52
RHD	4.73	5.07	13.77	13.80	1.073	2.060	8.12	10.09	21.90	27.03
NPK + RHD	4.67	5.27	9.89	10.74	1.440	2.153	8.86	11.12	24.15	20.35
PD + RHD	4.87	5.97	11.21	12.54	1.300	2.253	12.27	15.87	27.04	29.18
Mean	**4.67**	**4.99**	**10.89**	**11.47**	**1.279**	**1.827**	**10.27**	**12.65**	**22.21**	**23.45**
LSD (0.05)	**0.3608**	**0.5475**	**0.922**	**1.456**	**NS**	**0.6970**	**3.042**	**4.806**	**2.354**	**2.391**

CT = Control; NPK = nitrogen, phosphorous, potassium; PD = poultry dropping; RHD = rice husk dust; LSD = least significant difference.

Effect of different soil amendment sources on cocoyam tuber weight yield (ton/ha)

The results on tuber yield (Table 3) showed that cocoyam corms were significantly ($p < 0.05$) increased higher (22.17 tons/ha) in the 1st year by plots amended with poultry dropping (PD). The results indicated that all the treated plots increased the cocoyam corms significantly higher than the untreated plots. In the 2nd year of planting, PD + RHD amended areas though statistically the same with PD, NPK and NPK + RHD treated plots significantly ($p < 0.05$) increased the cocoyam corms better than RHD and the control plots.

It was obtained that cocoyam cormels in the 1st year of study varied significantly ($p < 0.05$) with PD + RHD treated plots giving the highest (26.25 t/ha) improvement (Table 3.3). This was followed by plots treated with sole NPK and PD (21.67 t/ha and 21.25 t/ha), respectively. The results revealed that the control plots performed statistically the same as all treated plots except the combined application of poultry dropping (PD) and rice husk dust (RHD) (PD + RHD) amendment. The results also showed significant improvement in the cocoyam cormels in the 2nd year of cropping. The highest significant ($p < 0.05$) yield weight of cormels (37.9 t/ha) was obtained from PD-amended plots. The results generally revealed that except for the NPK amended plots with a value of 28.6 t/ha, all other treated plots increasingly improved the cocoyam cormels higher than the control plots. The implication of this research finding is that sole NPK fertilizer in a short-term performance increases yield with a drastic reduction in yield weight on a long-term basis. This could be attributed to the high rainfall experienced in this zone with the application of sole NPK fertilizers being accompanied by a high rate of leaching losses, increased nutrient imbalance, reduced infiltration, and high bulk density (Nwite *et al.*, 2016a). In view of this, the combined use of chemical fertilizers and organic manures (organo-mineral fertilizer) has been suggested (Egbuchua and Enujeke, 2013). It is also believed that the degradation caused in the soil by the sole application of NPK fertilizer was a true reflection in the yields of cocoyam cormels within the 2nd years of cropping, as NPK fertilizer was higher in yield performance than sole RHD and the control on the 1st year.

Table 3 Effect of different soil amendment sources on cocoyam tuber weight yield (ton/ha)

Soil amendments	Corms (ton/ha)		Cormels (ton/ha)	
	Year 1	Year 2	Year 1	Year 2
CT	8.33	18.33	16.25	19.6
NPK	16.75	30.17	21.67	28.6
PD	22.17	32.92	21.25	37.9
RHD	15.25	20.83	15.00	30.4
NPK + RHD	14.58	27.92	19.17	31.5
PD + RHD	16.67	34.17	26.25	33.0
Mean	**15.62**	**27.39**	**19.93**	**30.2**
LSD (0.05)	**5.086**	**7.697**	**6.454**	**10.28**

CT = Control; NPK = nitrogen, phosphorous, potassium; PD = poultry dropping; RHD = rice husk dust;
LSD = least significant difference.

CONCLUSION

Findings from the study showed that integrated nutrient management practices used, across the studied soil chemical properties performed better than their sole application except in the case of available phosphorous. It is therefore concluded that the complementary use of organic and inorganic fertilizers has been reported to be a better soil fertility management strategy for crop production. It was also noted that the integration of poultry dropping and rice husk dust (PD + RHD) can be a quick restoration of degraded soil and cocoyam crop yield in Southeastern Nigeria.

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EFFECT OF CATTLE DUNG AND NITROGEN FERTILIZER ON GROWTH AND YIELD OF *AMARANTHUS CRUENTUS* (AMARANTH) IN SUDAN SAVANNA ZONE

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ABSTRACT

A study was conducted to at Makera, Dutsin-Ma Local Government Area, Katsina State, located in the Sudan Savanna Zone to evaluate the effect of cattle dung and different rates of nitrogen fertilizer on growth and yield of vegetable Amaranthus cruentus (Amaranth). The experiment was carried out during the dry season of 2022. The experimental design was a Randomized Complete Block Design (RCBD) laid out in a factorial arrangement (cattle dung and rates of nitrogen), replicated three times The treatment consisted of three cattle-dung levels (0, 5 and 10 t ha^{-1}) and four levels of nitrogen fertilizer (0, 40, 80 and 120 kg N ha^{-1}).. Application of cattle dung significantly ($p<0.05$) increased number of leaves per plant, number of branches per plant, plant height, stem girth and fresh shoot yield of Amaranthus cruentus. Application of 10 t ha^{-1} cattle dung produced significantly higher ($p<0.05$) amaranth fresh shoot yield (1,0891kg ha^{-1}) compared to the other rates used (8340 and 10442 kg ha^{-1}), obtained for application of 0 and 5 t ha^{-1} cattle dung. Nitrogen application also caused significant ($p<0.05$) increases on number of leaves per plant, number of branches per plant, plant height per plant, stem girth and fresh shoot yield. Fertilizing the soil with 120 kg N ha^{-1} gave significantly ($p<0.05$) higher amaranth fresh shoot yield (10900kg ha^{-1}) than fresh shoot yields at 0, 40 and 80 kg N ha^{-} (650, 9655 and 1035). Conclusively, application of 10 t ha^{-1} cattle dung and 120 kg N ha^{-1} was found to give better yields on growth and yieldof vegetable amaranth in the study area.it is therefore, recommended.

***Keywords**: Cattle dung, nitrogen fertilizer, , sudan savanna*

INTRODUCTION

Amaranth (*Amaranthus cruentus*) is a very important and common leafy vegetable in Nigeria, generally because it is used in many Nigerian dishes for soup, stew, salad porridge and as garnish (Abdullahi *et al*., 2019). Amaranthus plays a very starring role in human diet as a prominent source of proteins, vitamins, minerals, sugar, fibre and water needed for healthy body growth (Bailey, 1992). Its dietary value and tolerance or plasticity, places it as a suitable vegetable to reduce micronutrient malnutrition, hence enhancing food security (Munene, 2017). Low soil fertility has been one of the major challenges facing increased crop production in Sudan Savanna Zone. It has been reported that the Nigerian savanna soils have low organic carbon, total nitrogen, available phosphorus, effective CEC and exchangeable cations together with clay and silt contents (Singh, 1987). Therefore, it becomes imperative to add soil nutrient sources such as inorganic and organic fertilizers if optimal yield is expected for any crop. Vegetable amaranth, requires a lot of soil nutrients, mainly, nitrogen for better performance and enhanced yiel (Qiang *et al*., 2014). It also reported that leafy vegetables have a great nitrogen need because of its massive vegetative volume (Ayodele, 2002). However, farmers hardly add fertilizers to their leafy vegetables, even when they do, at very low quantities. The quest for safe and healthy soil, plus the growing interest in opting for alternatives to mineral fertilizers has led to increased use of organic fertilizers such as cattle dung. Cattle dung can easily be accessed in the Sudan Savanna. Cattle dung is rich in organic matter or humus with ability to improve the capacity of soils for water and nutrients adsorption (Grubben and Denton, 2004). Also, organic manure is known to give sustenance to cropping systems through better nutrient recycling and increasing physical, chemical and biological soil properties (Ojeniyi, 2000). Therefore, this study was designed to assess the effect of cattle dung and nitrogen fertilizeron growth and yield of vegetable amaranth (*Amaranthus cruentus*).

MATERIALS AND METHODS

The trial was conducted in the dry season of 2022, at Makera in Dutsin-Ma Local Government, Katsina State. The soil of the experimental site was sandy loam with the following properties: pH (0.01M $CaCl_2$), 6.09; organic carbon, 14.65 g kg^{-1}; total nitrogen, 1.7 g kg^{-1}; available phosphorus, 4.51 mg kg^{-1}; and exchangeable cations (cmol kg^{-1}) of $Ca^{2+,}$ 2.65; Mg^{2+}, 0.46; K^+, 0.19; and Na^+, 0.26; and CEC, 4.06 cmol kg^{-1}. The chemical analysis of cattle dung showed the following properties: total nitrogen, 14.01 g kg^{-1}; available phosphorus, 6.55 mg kg^{-1}; and exchangeable K, 4.5806 cmol kg^{-1}. The treatment consisted of three different levels of cattle-dung (0, 5 and 10t ha^{-1}) and four levels of nitrogen (0, 40, 80 and 120 kg N ha^{-1}). The experimental design was A Randomized Complete Block Design (RCBD) laid out in a factorial arrangement of different rates of cattle dung and nitrogen fertilizer, and replicated three times. *Amaranthus curentus* was used.

The nursery beds were prepared manually by tilling the soil repeatedly to give a good seed bed for seed germination. Cattle dung was incorporated on the seed beds, watered and allowed for two days before the amaranth seeds were sown by broadcasting. The experimental field was harrowed and consequently watered to give fine tilths of raised beds of 2 m x 2 m in basin for regular and easy irrigation. The different rates of cow dung (0, 5and 10 t ha^{-1}) were applied at two (2) weeks before transplanting . Seedlings were transplanted at three weeks after planting at a spacing of 40 cm x 20 cm. The field was irrigated every four days. Weeds were controlled using hoe at 2 WAT. Nitrogen was applied at two weeks after transplanting. Samples were taken on number of leaves, number of branches, plant height per plant (cm) and stem girth (mm) of amaranth at 2 and 4 weeks after transplanting (WAT), while fresh shoot yield (kg/ha) of vegetable amaranth was obtained at harvest. Data collected were subjected to analysis of variance (ANOVA) as described by Gomez and Gomez, (1984) using SAS package version 9.0 (SAS institute, 2002). Significant differences among treatments were separated using Duncan's Multiple Range Test at 5 % level of probability.

RESULTS

Application of 5 t cattle dung ha^{-1} significantly ($p<0.05$) increased number of leaves per plant, number of branches per plant and plant height per plant, but statistically similar ($p<0.05$) with application of 10 t ha^{-1} on number of leaves per plant, number of branches per plant and plant height per plant (Table 1). Application of 80 kg N ha^{-1} produced a significantly higher number of leaves per plant than other N rates, but statistically similar with the application of 120 kg N ha^{-1} on number of leaves. The application of 40 kg N ha^{-1} produced a significantly higher number of branches per plant and taller plants than other N rates, but statistically similar with the application of 80 and 120 kg N ha^{-1} (Table 1).

Application of 5 t cattle dung ha^{-1} significantly ($p<0.05$) increased stem girth per plant at both 2 and 4 WAT, but was statistically similar with application of 10 t ha^{-1} (Table 2). However, the application of 120 kg N ha^{-1} produced a significantly higher stem girth than other N rates (Table 2). Application of 10 t cattle dung ha^{-1} produced significantly higher fresh shoot yield than other rates of cattle dung (Table 2). Application of 5 and 10 t cattle dung ha^{-1} produced 25.2 and 30.6% increases in fresh shoot yield of vegetable amaranth when compared with no cattle dung application, respectively. Application of 120 kg N ha^{-1} produced significantly higher fresh shoot yield than application of 40 and 80 kg N ha^{-1}. Application of 40, 80 and 120 kg N ha^{-1} produced 11.6, 19.7 and 26 % increases in fresh shoot yield of vegetable amaranth when compared with no nitrogen application.

Application cow dung 0 t ha^{-1} and of 0 kg N ha^{-1} gave the lowest stem girth per plant at both stages (Table 3).

Table 1: Effect of cattle dung and nitrogen Fertilizer on number of leaves and number of branches and plant height (cm) of vegetable amaranth

	No. of leaves per plant		No. of branches per		Plant height (cm)	
	2 WAT	4WAT	2 WAT	4WAT	2 WAT	4WAT
Treatment						
Cattle Dung(C) (t ha^{-1})						
0	7.6^b	12.1^b	4.8^b	8.2^b	15.2^b	30.9^b
5	9.7^a	15.4^a	6.6^a	11.6^a	17.3^a	35.8^a
10	10.0^a	15.4^a	6.5^a	11.6^a	17.9^a	36.8^a
SE±	0.27	0.30	0.24	0.39	0.23	0.54
Nitrogen (N), (kg N ha^{-1})						
0	7.6^c	11.3^c	4.8^b	7.7^b	15.6^b	28.9^b
40	9.0^b	14.4^b	5.9^a	10.8^a	16.9^a	36.3^a
80	10.1^a	15.6^a	6.6^a	11.4^a	17.4^a	35.6^a
120	9.8^{ab}	15.8^a	6.5^a	11.9^a	17.3^a	37.1^a

Means followed by the same superscript(s) within the same column and treatment are not significantly different at 5 % level of probability using DMRT

Table 2: Influence of cattle dung and nitrogen application on stem girth (cm) and fresh shoot yield (kg ha^{-1}) of vegetable amaranth

	Stem girth (mm)		Fresh shoot yield (kg ha^{-1})
	2WAT	4WAT	
Treatment			
Cattle Dung (t ha^{-1})			
0	5.5^{b}	8.3^{b}	8340^{c}
5	6.5^{a}	9.3^{a}	10442^{b}
10	6.6^{a}	9.5^{a}	10891^{a}
SE±	0.10	0.10	132.5
Nitrogen (kg N ha^{-1})			
0	5.4^{c}	7.8^{d}	8650^{d}
40	6.2^{b}	8.7^{c}	9655^{c}
80	6.3^{b}	9.4^{b}	10358^{b}
120	6.9^{a}	10.2^{a}	10900^{a}
SE±	0.12	0.12	153.0

Note: **= Significant at 1 % level of probability. *=, Significant at 5 % level of probability Means followed by the same superscript(s) within the same column and treatment are not significantly different at 5 % level of probability using DMRT

Table 3: Interaction between cattle dung and nitrogen on stem girth at 2 and 4 WAT of vegetable amaranth.

Treatment	2 **WAT**			4 **WAT**		
	Cattle Dung (t ha^{-1})			**Cattle Dung (t ha^{-1})**		
	0	5	10	0	5	10
Nitrogen (kg N ha^{-1})						
0	4.5^{e}	6.2^{c}	5.5^{d}	6.7^{f}	8.7^{d}	8.0^{e}
40	5.5^{d}	6.3^{bc}	6.8^{abc}	7.6^{e}	9.0^{cd}	9.6^{bc}
80	5.5^{d}	6.6^{abc}	7.0^{ab}	9.1^{cd}	9.5^{bc}	9.6^{bc}
120	6.8^{abc}	6.9^{ab}	7.2^{a}	9.9^{b}	9.9^{b}	10.9^{a}
SE±		0.20			0.21	

Means followed by the same superscript(s) are not significantly different at 5% level of probability using DMRT.

DISCUSSION

The significant differences observed on number of leaves per plant, number of branches per plant, plant height per plant, stem girth and fresh shoot yield of vegetable amaranth after application of cattle dung could be attributed to the decomposition and subsequent mineralization of the incorporated cattle dung to release of nutrients for use by the amaranth for growth and development. This improved performance could also be attributed to the improvement in biological, physical and chemical properties of the soil due to application of cattle dung generally attributed to increased soil organic matter and enhanced the availability of the mineralized elements. and improvements in water retention, soil aeration, soil structure, cation exchange capacity (CEC) and microbial activity (Adesoji, 2015). Eifediyi and Remison, (2010) further reported that manure has the capacity to increase water holding capacity and lessen erosion incidence thereby causing more nutrients to be available to the soil. Okoli and Nweke, (2015) also rep[orted that organic manure has the ability to increase soil organic matter, being a container of soil nutrients, that improve soil organic activities, hence, assist to release nutrients required by the crop.

The marked increases observed on number of leaves per plant, number of branches per plant, plant height per plant, stem girth and fresh shoot yield of vegetable amaranth after nitrogen fertilization could be attributed to the important roles of nitrogen as a constituent of protein, nucleic acid and chlorophyll (Dehariya1, *et al*., 2019). These significant increases in growth attributes and fresh shoot yield of vegetable amaranth could also be linked to the vital role nitrogen plays as a component of protein and nucleic acids. (Haque *et al*., 2001) and also, as a basic constituent of many other compounds needed for processes in plant growth such as chlorophyll and many enzymes (Onasanya *et al*., 2009).

CONCLUSION

Based on the results obtained from this trial, it can be concluded that cattle dung (of 10 t ha^{-1}), application increased growth and yield attributes. 10 t ha^{-1} cattle dung ha^{-1} and 120 kg N ha^{-1} are thence, recommended for the production of vegetable amaranth in the study area.

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MAGNESIUM QUALITY ASSESSMENT IN RICE PRODUCING AREAS OF AFIKPO NORTH LOCALGOVERNMENT AREA OF EBONYI STATE, NIGERIA

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ABSTRACT

This study examined the forms and distribution of magnesium in soils of major rice producing areas Afikpo North LGA of Ebonyi state. Soil samples from identified four major rice producing clans (Afipko. Amasiri, Itim and Unwana) in Afikpo North LGA were collected in three replicates for each location at three depths (0 – 15 cm, 15 – 30 cm and 30 – 45 cm), giving a total of 12 observational units. These samples were analyzed in the laboratory using standard methods for physical and chemical properties and forms of magnesium. The experimental design wasa factorial in Randomized Complete Block Design (RCBD).Results of the physical and chemical properties of the soils showed that there was variability of these properties with respect to location and depth. Location, depth, and interaction showed significant variations (P <0.00.05). However, the texture was generally clayey loam and the soils were acidic. Afikpo had the highest amount of the different forms of magnesium, while the least values were obtained in soils of Itim. Apart from non-exchangeable and mineral magnesium forms which increased with depth, all other forms of magnesium studied decreased with depth. Afikpo soil is considered rich in magnesium compared to other rice producing locations studied. The occurrence of the high unavailable forms of magnesium in these soils shows the effect of high magnesium sorption and therefore liming to reduce acidity and cation sorption is recommended.
Keyword: *Magnesium, Status, Assessment, Rice and Afikpo*

INTRODUCTION

Magnesium is widely recognized as the eighth most abundant mineral element on the earth with an estimated crystalabundance of 2.08% (Rosanoff, 2018). It is an essential element that is necessary for most physiological and biochemical processes in plant system (Brady and Weil, 2008). It is important in the formation of chlorophyll for photosynthesis, activation of many plant enzymes needed for growth and in the regulation of opening and closing of stomata (Khalon, 2008). Apart from crop, magnesium is known to affect arrays of soil properties including pH, nutrient availability, help mitigate the effects of aluminum toxicity and increase phosphorus availability in acid soil (Wang, Mulongoy and Tabatabai, 2005) Various factors such as parent material, organic matter content, land use type, minerarological content and physical state of the soil influence the distribution and availability of magnesium to growing plants (Mikkelson, 2010).

The relationship between magnesium in soil and crops is well established and has been widely studied in scientific community (Barber, 2009). According to Chien, (2012),magnesium and other essential nutrients such as calcium are important for optimizing plant growth and yield, thus, understanding the relationship between magnesium in the soil and crops is crucial for managing soil fertility and promoting healthy growth in agriculture and horticulture.

Rice is one of the most staple foods grown largely in Afikpo North LGA of Ebonyi State and yield optimization depends among other soil factors, on the availability of magnesium. Information on the magnesium status of soils ofrice producing areas of Afikpo North LGA is still dearth. This study was therefore to bridge the

MATERIALS AND METHODS

The study was conducted in four different Villages in Afikpo North L.GA namely Afikpo, Amasiri, Uwana and Itim, all of which have 'clay shale' as their parent materials. Afikpo is located between latitude 5.51°N longitude 7.56°E, Amasiri located between latitude 5.54°N, longitude 7.54°E, Unwana located between latitude 5.51°N longitude 7.55°E and Itim located between latitude 5.47°N, longitude 7.55°E. Afikpo North LGA is found within the rainforest zone of Nigeria with avareage annual rainfall of between 2000 -2192mm. The mean temperature is between 25.86°C-35.46°C with a relative humidity of about 74%. Agriculture, especially rice and cassava production, is the main occupation of the people. Sampling sites were selected using free survey sampling techniques and soil samples were collected from each location in three replicates at 0-15 cm, 15-30 cm and 30-45 cm soil depths. These soils were analyzed in the laboratory for physical and chemical properties according to standard methods.

The various forms of magnesium including water soluble, exchangeable, non-exchangeable, fixed and mineral magnesium were determined according to the method of Jackson (1958) as described by Udo et al., 2009).

Statistical Analysis

This study was considered a 4 x 3 factorial in Randomized Complete Block Design (RCBD) in which the location and soil sampling depths were the two factors under consideration. Data obtained were subjected to analysis of variance and means separated, while correlation analysis was used to compare relationships.

RESULTS AND DISCUSSIONS

Physical and Chemical Properties of the soils of the Locations

The textural class of the soils irrespective of location and depth was clayey loam. The soils were generally acidiclow in available P, but high in most basic cations. These soils can support rice production especially when acidity iscontrolled by liming.

Magnesium forms

Solution Mg

Solution Mg concentration varied under the different locations of the studied soils and ranged from 0.14 – 0.55Cmolkg^{-1} with Unwana soils having the highest mean of solution Mg of 0.55 Cmolkg^{-1}, followed by Afikpo with 0.47 Cmolkg^{-1}, and Amasiri with 0.20 Cmolkg^{-1}, while Itim had least with 0.14 Cmolkg^{-1}. The finding is a bit similar with the finding of Obasi *et al.*, (2017), whose solution Mg ranged Means were 1.67, 1.02 and 2.58 mgkg^{-1}for the pedons 1, and 3 for Abakaliki highland, and Abakaliki lowland respectively.

Exchangeable Mg

Exchangeable Mg concentration also varied under the different locations and ranged from 0.49 –1.08 Cmolkg^{-1} with Afikpo soils having the highest exchangeable Mg mean of 1.08 Cmolkg^{-1}, followed by Amasiri with 0.67 Cmolkg^{-1}, and Unwana with 0.55 Cmolkg^{-1} while Itim had the least value of 0.55 Cmolkg^{-1}. A critical Mg value was given as 0.40 Cmolkg^{-1} (Adeoye & Agboola, 1985).

Non - Exchangeable Mg

Non-Exchangeable Mg concentration equally varied under the different locations and ranged from 0.10 – 2.26 Cmolkg^{-1} with Afikpo soils having the highest non-exchangeable Mg mean of 2.26 cmol/kg, followed by Amasiri with 1.52 Cmolkg^{-1}, and Unwana with 1.11 Cmolkg^{-1} while Itim had least, with a value of 0.10 Cmolkg^{-1}. These values are lower than those reported in the findings of Okpamen *et al* (2013), which reported values that ranged from 7.79 to 24.34 Cmolkg^{-1} (between 0 - 15 cm) in the four parent materials studied

Table 4.3: Forms and Distribution of Magnesium in the Soils (cmol/kg)

0-15	0.30	0.71	1.41	2.91	5.26
15-30	0.30	0.74	1.49	3.14	5.65
30-45	0.02	0.57	1.67	3.22	5.45
Mean	**0.20**	**0.67**	**1.52**	**3.09**	**5.45**
			Itim		
0-15	0.16	0.46	1.10	2.35	3.98
15-30	0.15	0.46	1.10	2.35	3.98
30-45	0.11	0.56	1.14	2.67	4.46
Mean	**014**	**0.49**	**1.10**	**2.46**	**4.14**
			Unwana		
0-15	0.15	0.51	1.11	2.61	4.41
15-30	0.14	0.57	1.11	2.88	4.35
30-45	0.15	0.56	1.12	2.88	4.78
Mean	**0.15**	**0.55**	**1.11**	**2.79**	**4.51**

LSD p = 0.05					
Location	0.023	0.039	0.005	0.042	0.007
Depth	0.020	0.034	0.004	0.036	0.006
L X D	0.041	0.068	0.008	0.072	0.012

Depth Cm	Solution Mg	Exch Mg	Non-Exch Mg	Mineral Mg	Total Mg
		Afikpo			
0-15	0.53	1.10	1.89	3.28	6.77
15-30	0.46	1.12	2.35	3.59	7.50
30-45	0.43	1.03	2.56	3.78	7.35
Mean	**0.47**	**1.08**	**2.26**	**3.55**	**7.20**

Mineral Mg

Mineral Mg concentration varied under the different locations and ranged from 2.46 – 3.55 Cmolkg^{-1} with Afikpo soils having the highest Mineral Mg mean of 3.55 Cmolkg^{-1}, followed by Amasiri with 3.09 Cmolkg^{-1}, and Unwanawith 2.79 Cmolkg^{-1} while Itim had least with Mineral Mg of 2.46 Cmolkg^{-1}. This validates the findings of Osemwota*et al* (2009) who indicated that the Mg content (Cmolkg^{-1}) of the soils ranged from 2.94 to 5.04 with a mean of 3.86±0.33

Total Mg

The mean values of total magnesium varies under the different locations and ranged from 4.14 – 7.20 Cmolkg^{-1} withAfikpo soils having the highest mean of 7.20 Cmolkg^{-1}, followed by Amasiri with 5.45 Cmolkg^{-1}, and thenUnwana, with 4.51 Cmolkg^{-1} while Itim had the least with a value of 4.14 Cmolkg^{-1}. These values are a bit lower when compared with the findings of Osemwota *et al.* (2009) whose results of total Mg content (Cmolkg^{-1}) of the soils studied ranged from 7.35 to 12.60 with a mean of 9.65±0.79.

Relationship between Some Soil Chemical Properties and Forms of Magnesium

Table 4. Correlation Coefficient between Some Soil Chemical Properties and Forms of Magnesium

	pH	OC	TN	AV.P	TEB	TEA	BS
SOL MG	0.610	0.582	0.745	0.783	0.576	0.090*	0.961*
EXCH MG	0.715	0.663	0.738	0.861*	0.637	0.179	0.967*
NEMG	0.739	0.575	0.825*	0.880*	0.534	0.062	0.922*
MIN. MG	0.872*	0.775	0.680	0.956*	0.713	0.335	0.919*
TOTAL MG	0.589	0.028	0.999**	0.703	-0.052	-0.492	0.533

*Correlation is significant at the 0.05% level (2-tailed),** Correlation is significant at the 0.01% level (2-tailed)

CONCLUSION

Significant variations in forms of magnesium with location and depth were observed. Soluble magnesium was relatively low in these soils below the critical value for rice production. The study therefore recommended the addition of magnesium fertilizers in addition to other fertilizers to promote profitable and sustainable rice production in these locations.

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PRODUCTIVITY OF VEGETABLE AMARANTH (AMARANTHUS CRUENTUS) AS INFLUENCED BY INTRA ROW SPACING AND CATTLE DUNG APPLICATION IN SEMI-ARID ENVIRONMENT

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ABSTRACT
A trial was carried out to assess the effect of intra row spacing and cattle dung on productivity of vegetable amaranth (Amaranthus cruentus) in a semi-arid environment in the dry season of 2022 at Makera in Dutsin-Ma Local Government, Katsina State. The experimental design was Randomized Complete Block Design (RCBD) in a factorial arrangement of different intra row spacings and rates of cattle dung and replicated three times The treatments consisted of three intra row spacing (10, 20 and 30 cm) and four levels of cattle-dung (0, 5, 10 and 15 t ha^{-1})). Intra row spacing significantly ($p<0.05$) increased number of leaves per plant, number of branches per plant, plant height per plant, stem girth and fresh shoot yield of vegetable amaranth. Transplanting vegetable amaranth at 10 cm spacing produced higher ($p<0.05$), fresh shoot yield of amaranth. Transplanting vegetable amaranth at spacing 10 and 20 cm produced 184.2 and 106.7 % increases in fresh shoot yield of vegetable amaranth compared with transplanting vegetable amaranth at 30 cm spacing. Application of cattle dung significantly ($p<0.05$) increased number of leaves per plant, number of branches per plant, plant height per plant, stem girth and fresh shoot yield of vegetable amaranth. Incorporation of 10 t/ha cattle dung produced significantly ($p<0.05$) higher amaranth fresh shoot yield than that obtained with application of 0, 5 and 15 t/.ha cattle dung.. Intra row spacing and cattle dung at spacing of 10 cm and 10 t cattle dung ha^{-1} are recommended for the production of vegetable amaranth in the study area.

Keywords: *Intra row spacing, cattle dung, amaranth, semi-arid*

INTRODUCTION
Amaranth (*Amaranthus cruentus*) is a very popular leafy vegetable in Nigeria, with usage in almost every home. Generally, vegetables like amaranth are fast growing and low input requiring crops making it a good and quick source of income for poor resource farmers. However, vegetable amaranth is planted without a proper spacing (inter or intra row), with a belief that leafy vegetables find their space. Plant spacing is a prime factor in growth expression of plant. Inproper spacing limits or narrows available rhizosphere and photoshere needed for the plant to explore and exploit for growth, and invariably lessens full expression of growth characteristics, hence, hinders dry matter accumulation (Adesoji *et al*., 2020). It has been reported that maximum light interception is achievable when optimum plant space is met beginning from early growth (Rajesh *et al*., 2017). For better yield, optimal plant population must be attained for efficient photosynthesis. It has been reported by Lukman and Adesoji, (2021) that using inorganic fertilizers is a common denominator in our farming communities but these fertilizers are seldom applied at the recommended quantities, hence, low crop yields. Therefore, it is very worthwhile to use alternatives like cattle dung which is easily available in the study area. Cattle dung is good generator of organic manure and as a major factor for long term cropping in the tropics because due to slow mineralization of organic manures for enhanced crop yield (Gambo *et al*., 2008). Therefore, this experiment was conducted to evaluate the productivity of vegetable amaranth (*Amaranthus cruentus*) as influenced by intra row spacing and cattle dung in semi-arid environment.

MATERIALS AND METHODS
The experiment was carried out in the dry season of 2021/2022 dry season at Makera in Dutsin-Ma Local Government, Katsina State. The experimental soils were assessed to be sandy loam with the following properties: pH (0.01M $CaCl_2$), 6.09; organic carbon, 14.65 g kg^{-1}; total nitrogen, 1.7 g kg^{-1}; available phosphorus, 4.51 mg kg^{-1}; and exchangeable cations (cmol kg^{-1}) of Ca^{2+}, 2.65; Mg^{2+}, 0.46; K^{+}, 0.19; and Na+ , 0.26; and CEC, 4.06

cmol kg-1. The cattle dung chemical analysis revealed the following properties: total nitrogen, 14.01 g kg^{-1}; available phosphorus, 6.55 mg kg^{-1}; and exchangeable K, 4.5806cmol kg^{-1}. The experimental design was a Randomized Complete Block Design (RCBD), laid out as a factorial (intra row spacing and rates), of cattle dung and replicated three times. The treatments were made up of three intra row spacing (10, 20 and 30cm) and four rates of cattle dung (0, 5, 10 and 15t ha^{-1}). The gross plot size was 2m x 2m ($4m^2$) and net plot was 1.5m x 2m ($3m^2$). *Amaranthus curentus* was used.

Nursery beds were prepared by tilling the soil into suitable orgood seed beds for seed germination. Cattle dung was incorporated on the seed beds, watered and allowed two days before planting of amaranth seeds by broadcasting. The experimental field was harrowed and consequently watered to give fine tilth of raised beds of 2 m x 2 m in basin for irrigation. The different rates of cattle dung (0, 5, 10 and 15t ha^{-1}) were applied two (2) weeks before transplanting by broadcasting in the respective plots and mixing thoroughly into the seed beds using the small African hand-held hoe. Seedlings were transplanted at three weeks after planting at intra row spacings of 10, 20 and 30 cm and 40 cm inter row spacing. Irrigation was done every four days using. Weeds were controlled using the small African hand-held hoe at 2 WAT. Data collection were on number of leaves, number of branches, plant height per plant (cm) and stem girth (mm) of amaranth at 2 and 4 weeks after transplanting (WAT), while fresh shoot yield (kg/ha) of vegetable amaranth was collected at harvest. All data were subjected to analysis of variance (ANOVA) as described by Gomez and Gomez (1984), using SAS package version 9.0 (SAS institute, 2002). Significant differences among treatment were separated using Duncan's Multiple Range Test (Duncan, 1955) at 5 % level of probability.

RESULTS

Intra-row spacing significantly ($p<0.05$) affected number of leaves per plant at 2 WAT only, and number of branches per plant and plant height at both 2 and 4 WAT (Table 1). Transplanting amaranth at spacing the of 20 cm produced significantly ($p<0.05$) higher number of leaves, number of branches per plant and plant height than other plant spacings (10 and 20 cm), but statistically similar ($p<0.05$) with planting at 10 cm on number of leaves at 2 WAT and 30 cm on number of branches at 2 WAT. Application of cow dung was significant ($p<0.05$) on number of leaves per plant, number of branches per plant and plant height at both 2 and 4 WAT (Table 1), where application of 10 t cow dung ha^{-1} produced significantly ($p<0.05$) higher number of leaves per plant, number of branches per plant and taller plants than other rates of cattle dung.

Intra row spacing was only significant ($p<0.05$), on stem girth at 4 WAT. Spacing at 30 cm, eventhough statistically similar ($p<0.05$), transplanting at 20 cm, produced larger stem girth (Table 2). Application of cow dung was significant ($p<0.05$), on stem girth of amaranth at both 2 and 4 WAT (Table 2) where application of 10 t cow dung ha^{-1} produced significantly ($p<0.05$) larger stem girth than other rates of cattle dung. Intra row spacing was significant ($p<0.05$) on fresh shoot yield of amaranth at spacing 10 cm with higher fresh shoot yield at spaces of 20 and 30 cm (Table 2). Transplanting vegetable amaranth at 10 and 20 cm produced 184.2 and 106.7 % increases in fresh shoot yield of vegetable amaranth to 30 cm spacing. Application of 5, 10 and 15 t cow dung ha^{-1} produced 45.3, 60.3 and 57.9 % increases in fresh shoot yield of vegetable amaranth when compared with no cow dung application. Generally, intra row spacing and cattle dung 10 and 10 t cattle dung ha^{-1}, gave significantly better ($p<0.05$), fresh shoot yield of amaranth while lowest fresh shoot yield was obtained at transplanting at spacing of 10 cm plus no cattle dung (Table 3).

Table 1: Influence of intra row spacing and application of cattle dung on number of leaves per plant, number of branches per plant and plant height per plant (cm) of vegetable amaranth

	No. of leaves $plant^{-1}$		No. of branches $plant^{-1}$		Plant height (cm)	
	2 WAT	4WAT	2 WAT	4WAT	2 WAT	4WAT
Treatment						
Intra row spacing (I)						
10	8.9^{a}	12.7	5.4^{b}	8.4^{b}	14.6^{b}	28.6^{b}
20	9.1^{a}	13.2	5.7^{a}	8.7^{a}	15.4^{a}	30.1^{a}
30	8.2^{b}	13.1	5.6^{ab}	8.3^{b}	14.5^{b}	28.2^{b}
SE±	0.13	0.18	0.09	0.11	0.13	0.31
Cattle dung (C)(t ha^{-1})						
0	7.6^{c}	10.0^{c}	4.8^{b}	6.5^{c}	12.8^{c}	22.1^{c}
5	8.9^{b}	13.1^{b}	5.6^{a}	8.5^{b}	15.2^{b}	30.7^{b}
10	9.4^{a}	14.3^{a}	5.9^{a}	9.4^{a}	15.4^{b}	30.9^{ab}
15	9.2^{ab}	14.4^{a}	5.9^{a}	9.5^{a}	15.9^{a}	31.9^{a}
SE±	0.15	0.21	0.10	0.12	0.15	0.36

Means followed by the same superscript(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT

Table 2: Influence of intra row spacing and application of cattle dung on stem girth (mm) and fresh shoot yield (kg ha^{-1}) of vegetable amaranth

	Stem girth (mm)		**Fresh shoot yield (kg ha^{-1})**
	2WAT	4WAT	
Treatment			
Intra row spacing (I)(cm)			
10	4.9	6.5^{b}	16018a
20	4.9	6.7^{ab}	11654^{b}
30	4.8	6.8^{a}	5637^{c}
SE±	0.11	0.10	146.8
Cattle dung (C)(t ha^{-1})			
0	4.2^{c}	5.6^{c}	7881^{c}
5	4.8^{b}	6.7^{b}	11450^{b}
10	5.2^{ab}	7.1^{a}	12635^{a}
15	5.3^{a}	7.3^{a}	12445^{a}
SE±	0.13	0.11	169.5

Means followed by the same superscript(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT

Table 3: Interaction between cow dung and intra-row spacing on fresh shoot yield at 4WAT of vegetable amaranth.

	Fresh shoot yield		
Treatment	10cm	20cm	30cm
Cow dung (t ha^{-1})			
0	11345^{e}	8112^{f}	4187^{h}
5	15818^{b}	12875^{cd}	5656^{g}
10	18344^{a}	13379^{c}	6183^{g}
15	18563^{a}	12252^{d}	6520^{g}
SE±		293.5	

Means followed by the same letters(s) are not significantly different at 5% level of probability using DMRT

DISCUSSION

The significant increases observed on intra spacing for number of leaves per plant, number of branches per plant, plant height per plant, stem girth and fresh shoot yield of vegetable amaranth could be attributed to the fact that plant spacing influences due to photosphere and rhizosphere exploitation by the plants (Ibeawuchi *et al*., 2008). Higher results at 10 cm on fresh shoot amaranth could be attributed to maximum light interception, possible when optimum plant space is made through the growth stages (Rajesh *et al*., 2017), especially for leafy vegetables like amaranth. This could also be that spacing at 10 cm enabled large plant populations which aggregately produced higher weight than those amaranth transplanted at 20 and 30 cm spacings.

The significant increases on number of leaves per plant, number of branches per plant, plant height per plant, stem girth and fresh shoot yield of vegetable amaranth after application of cattle dung could be attributed to the organic matter generated as a result of cattle dung decomposition. Adesoji, (2015) reported that this enables slow but a steady release of nutrients, increase soil microbial population and improve soil quality leading to more vigorous root establishment and nutrient absorption of mineralized nutrients for growth and development. Khan *et al*., (2017) reported that application of organic material has the ability to improve plant nutrient availability, bulk density and water holding capacity of the soil and in turn, increases vegetative growth through accelerated division of meristematic tissues and metabolic reactions for increased growth and enhanced yields. Significant increase observed on fresh shoot yield of amaranth after application of cattle dung may be attributed to the increases observed on growth parameters measured.

CONCLUSION

From the results obtained, it can be concluded that intra row spacing and cow dungincreased growth and development of amaranth, especially at 10 cm spacing. The spacing of 10 cm and application of 10 t cattle dung ha^{-1} are therefore, recommended as the most appropriate rates for the production of vegetable amaranth in the study area.

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EFFECT OF SOWING METHODS, PRE- EMERGENCE HERBICIDES AND TIME OF APPLICATION ON GROWTH AND YIELD OF SESAME (*SESAMUM INDICUM* L.)

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ABSTRACT

This study was conducted to determine effect of sowing methods, pre-emergence herbicides and timing on growth and yield of sesame crop. The experiment was conducted at the Teaching and Research Farm, Faculty of Agriculture, Nasarawa State University, Keffi, for two consecutive cropping seasons (2021 and 2022). The experimental design was a Randomized Complete Block Design, laid out as a split plot with three replications. The treatment consisted of two different pre-emergence herbicides (Diuron at 0.8 kg a.i. ha^{-1}*and S-metolachlor at 1.5 kg a.i.* ha^{-1}*), applied at three timings, [3 days before sowing (DBS), immediately after sowing and 3 days after sowing (3 DAS)], hoe-weeding at 21 and 42 DAS and a weedy check (control) and two methods of sowing (drilling and broadcasting). The treatments consisted of a total of 24 treatment combinations. The methods of sowing was the main plots and pre-emergence herbicides, time of application, the sub-plots. The plot size was 3 m x 4 m with alleyways of 1.0 and 0.5 m between replications and plots respectively.The results indicated that sowing methods in 2021 and 2022 indicated that drilling gave the highest (*$p<0.05$*), sesame yields, and plant height, especially when sesame was grown and treated with pre-emergence herbicide application before sowing. The highest (*$p<0.05$*), weed control efficiency was achieved when pre-emergence herbicides were applied before sowing using Metolachlor 3 DBS, with drilling method giving higher (*$p<0.05$*), weed control efficiency than conventional broadcasting. Overall, this study indicated that pre-emergence herbicides applied before sowing and drilled gave higher (*$p<0.05$*), grain yield and weed control efficiency.*

Keywords: *Sowing methods, Pre-emergence herbicides, , Sesame*

INTRODUCTION

Sesame, the "queen of oilseeds", is known as *Sesamum indicum L*. Sesame is a nutrient-dense plant containing oil, protein, lime ash, crude fiber, oxalate, soluble carbohydrates and phytate. Asia is the sixth largest producer, with Africa and Latin America ranking 13th and 3rd, respectively. The largest producers include Myanmar, India and China, while the lowest producers are Mali, Bangladesh, Paraguay and Benin. According to FAO statistics (FAOSTAT, 2022; Dossa, *et al.*, 2023), these major sesame producing countries account for 92.6 % of global sesame production. Africa accounts for 25 % of the global production, with Sudan, Uganda, and Nigeria leading. Nigeria's major sesame producing states are: Benue, Nasarawa, Jigawa, Yobe, Gombe, Kano, Plateau, Katsina, and Kogi States, with Benue and Nasarawa leading (Mohammed, 2021). These states cultivate over 80,000 hectares of sesame with an annual average yield of 40,000 MT. In 2010, Nigeria exported 140,850 MT of sesame, earning a gross income of $139,000,000 (FAO 2021)

The production of sesame is challenged by both natural and man-made problems resulting in a decrease in the productivity of sesame. Key among the problems of production are presence of weeds and a lack of expertise to control (Zakar and Shamsuddeen 2020). The presence of weeds without proper weed management measures, have decreased yields by 50-75 % - especially in the initial stages of growth (Sharma*et al.,* 2021; Lins, *et al.,* 2019). Hence, it is crucial to prevent weed interference to ensure optimal productivity and profitability for sesame (Souza*et al.,* 2020). Selecting appropriate management techniques is a crucial especially at the initial stage of growth.

In the Sudan Savanna Zone of Nigeria, hoe-weeding is the conventional weed control method practiced by farmers. However, this technique is strenuous and can damage growing roots and branches. Accessibility to labor is also unreliable, leading to untimely weeding and greater yield loss. Chemical weed control has emerged as a game-changing method worldwide, as it is better suited to large-scale crop production. Not only is it labor-saving, but it also offers a more cost-effective solution to weed control. Reports have shown that herbicide usage is a more profitable method of crop production than manual hoe-weeding (Ekeleme *et al.*, 2021; Olusegun *et al.*, 2019). However, research on chemical weed control in sesame has primarily been restricted to the Southern Guinea Savanna Zone of Nigeria..

The conventional approach to weed control is no longer feasible in the commercial cultivation of sesame because of its high operational expenses, weak seedling vigour, competitiveness, and inadequacy of labor. As a result, the usage of pre-emergence herbicides has become crucial for large-scale sesame production to ensure timely and effective weed control.

MATERIALS AND METHODS

Experimental Site

Field experiment was conducted during the cropping seasons of 2021 and 2022, at the Teaching And Research Farm of Faculty of Agriculture, Shabu-Lafia Campus, Nasarawa State University, Keffi. The study area falls within Southern Guinea Savanna Agro ecological zone of Nigeria (NIMET, 2016).

Treatments and Experimental Design

The experiment was conducted at the Teaching and Research Farm, Faculty of Agriculture, Nasarawa State University, Keffi, for two consecutive cropping seasons (2021 and 2022). The experimental design was a Randomized Complete Block Design, laid out as a split plot with three replications. The treatment consisted of two different pre-emergence herbicides (Diuron at 0.8 kg a.i. ha^{-1}and S-metolachlor at 1.5 kg a.i. ha^{-1}), applied at three timings, [3 days before sowing (DBS), immediately after sowing and 3 days after sowing (3 DAS)], hoe-weeding at 21 and 42 DAS and a weedy check (control) and two methods of sowing (drilling and broadcasting). The treatments consisted of a total of 24 treatment combinations. The methods of sowing was the main plots and pre-emergence herbicides, time of application, the sub-plots. The plot size was 3 m x 4 m with alleyways of 1.0 and 0.5 m between replications and plots respectively. Herbicides were applied using CP3 pressurized sprayer.

Land Preparation

The experimental field was sprayed with glyphosate as a pre-tillage herbicides to control the emerged weeds after which the weeds were burnt. The field was then ploughed, harrowed, leveled using an Afrcan hand-held hoe, and marked out 10 m x 70 m. Raised beds of 20 cm height were constructed manually, labeled and placed according to the treatment combinations on each plot.

Fertilizer application

NPK 15:15:15 was applied to each plot to at 75 kg N and 50 kg P, with the full rate of P applied by incporation before sowing. The application of N however, was done in 2 equal splits before planting as starter dose and the second applied at 6 WAS 15 cm away from stands in a continuous band.

Experimental Materials

Sesame seeds (NCRIBEN 01M) were obtained from National Cereal Research Institute, Badeggi-Niger State, Nigeria. Sesame seeds were broadcasted August, 2021 and 2022. Drilled seeds were at the rate of 3 kg/ha, at a spacing of 90 cm between the rows. Fertilizer NPK 15:15:15 and urea and herbicides (Glyphosate - Touchdown®, Diuron and S-Metalachlor – Dual Gold®) was purchased from an Agrochemical shop in Lafia.

Data Collection

Five (5) plants were randomly tagged in each net plot. Data was taken on the following parameters:

Plant height

This was taken at 6 and 9 WAS. Height was measure from the soil level to the tip of the apical bud with a graduated meter ruler (Imoloame, 2009).

Phytotoxicity rating

This was taken at 3, 6 and 9 WAS by visual observation using a scale of 1 to 9, where 1 = no crop injury and 9 = complete crop kill (Imoloame, 2009).

Weed dry matter:

This was done at 3, 6 WAS and at harvest. This was done by harvesting weed biomass by throwing three (3) quadrats (50 cm x 50 cm) in each experimental plot. The weeds were oven-dried and weighed (Imoloame, 2009).

Grain yield/ha:
This was determined after harvest and after threshing. Grain yield/plot was weighed and recorded (Imoloame, 2009

Statistical Analysis
Data were subjected to analysis of variance (ANOVA) using the General Linear Model Procedure using GENSTAT software (2008 Ed.). Significant differences were separated using Fisher's Least Significant Difference at 5 % level of probability.

Results and Discussion
Table 1: Effect of sowing methods and timing herbicide application on Sesame height at 6 and 9 WAS in 2021 and 2022 cropping seasons.
Height of sesame was significantly ($p<0.05$) influenced by method of sowing used. Across both the 6-week and 9-week after sowing (WAS) periods, plants grown through drilling grew taller than those grown through broadcasting. This trend was consistent over the two years of the trial, with the drilling method yielding the highest at 9 WAS in both years. The possible reason for this disparity is that the irregular spacing between plants using the broadcast method may lead to reduced plant population and an increase in competition with weeds for limited nutrients and water, hindering plant growth. These findings contradict those of Katanga and Buba (2014), who reported that most sowing methods had little impact on plant height, except for broadcasting, which resulted in taller plants during all sampling stages.
All of the treatments administered in the experiment resulted in tall plants compared to those hoe weeding. The mean height of the plants at 9 weeks after sowing (9 WAS) in both 2021 and 2022 showed significant differences ($p<0.05$). However, Diuron at 0 DAS and at 2 DAS at 6 WAS in 2021, as well 2 DAS and Metolachlor 2 DAS treatments at 6 WAS in 2022, produced significantly shorter plants. The Metolachlor 3 DBS, Metolachlor 2 DAS, and Metolachlor 0 DAS treatments at 9WAS in both years did not have significant effects on plant height. In 2021, the combined means of Metolachlor 6 WAS and the weedy check resulted in significantly shorter plants.
During the entirety of the sample period, the correlation between the technique of planting and the timing at which herbicides were applied did not produce any significant ($p<0.05$), on the height of the plants.

HEIGHT

	6WAS		9WAS	
Treatment	**2021**	**2022**	**2021**	**2022**
Sowing Method (S)				
Drilling	4.02*	3.93*	5.65*	5.67*
Broadcasting	3.25*	3.15*	4.41*	4.88*
SE ±	0.11	0.50	0.06	0.22
LSD	0.47	0.22	0.24	0.94
Timing of Herbicide Application(T)				
Diuron 3DAS	4.12*	4.07*	5.12**	5.17**
Diuron 0DAS	3.25*NS	3.27*	4.67*	4.72*
Diuron 2DAS	3.13NS	3.17NS	4.37*	4.43*
Metolachlor 3DBS	3.85*	3.72*	5.17NS	5.98*
Metolachlor 0DAS	3.62*	3.50*	5.05NS	5.67*
Metolachlor 2DAS	3.52NS	3.33NS	4.87NS	5.60NS
HW 3 & 6WAS	4.27*	4.07*	6.18**	6.17**
WC	3.32	3.22	4.82	4.57
SE ±	0.12	0.10	0.12	0.10
LSD	0.24	0.21	0.22	0.20

Interaction S x T	NS	NS	NS	NS

Means in columns followed by the same symbol (*) within the same treatment group are statistically different at either significant at 1 % and 5 % levels of probability; Ns = not significant; WAS=weeks after sowing, WC= weedy check

Table 2: Effect of sowing methods and timing of pre-emergence herbicide application on sesame injury at 3, 6 and 9 WAS in 2021 and 2022

PHYTOTOXICITY RATING

	3 WAS		6 WAS		9 WAS	
Treatment	2021	2022	2021	2022	2021	2022
Sowing methods (S)						
Drilling	3.35^{NS}	3.30^{NS}	1.91^{NS}	1.87^{NS}	1.34^{NS}	1.27^{NS}
Broadcasting	3.99^{NS}	4.47^{NS}	2.90^{NS}	3.17^{NS}	1.48^{NS}	1.77^{NS}
SE±	0.30	0.21	0.24	0.38	0.10	0.15
LSD	1.28	0.91	1.04	1.63	0.44	0.65
Timing of HB Application (T)						
Diuron 3 DBS	3.10*	2.87*	2.17^{NS}	2.13^{NS}	1.00^{NS}	1.00^{NS}
Diuron O DAS	4.37*	4.73*	2.27^{NS}	2.33^{NS}	1.00^{NS}	1.00^{NS}
Diuron 2 DAS	7.60**	7.83**	5.30**	5.43**	3.87**	4.00**
Metolachlar3DBS	2.77*	2.83*	1.62^{NS}	1.90^{NS}	1.00^{NS}	1.00^{NS}
Metolachlar O DAS	3.87*	3.83*	2.20^{NS}	2.70^{NS}	1.00^{NS}	1.00^{NS}
Metolachlor 2 DAS	5.67**	6.97**	3.70*	3.67	1.50*	2.13*
HW 3 & 6 WAS	1.00^{NS}	1.00^{NS}	1.00^{NS}	1.00^{NS}	1.00^{NS}	1.00^{NS}
WC	1.00^{NS}	1.00^{NS}	1.00^{NS}	1.00^{NS}	1.00^{NS}	1.00^{NS}
SE±	0.42	0.25	0.45	0.42	0.34	0.35
LSD	0.87	0.51	0.91	0.86	0.69	0.71
Interaction S x T	NS	NS	NS	NS	NS	NS

Means in columns followed by the same symbol (*) within the same treatment group are statistically different at either significant at 1 % and 5 % levels of probability; Ns = not significant; WAS=weeks after sowing, WC= weedy check.

There were no significant negative effect on the sesame crop due to the sowing methods used in the experiment, even with the pre-emergence herbicides used at 3WAS, 6WAS, and 9WAS, as evidenced by Table 2 in both years of the study. However, in both years of the experiment, the pre-emergence herbicides applied had significant ($p<0.01$) phytotoxic effect on sesame, implying higher absorption herbicides at higher concentrations in sandy loam soils. This result is consistent with Imoloame *et al*., (2010) and Grichar *et al*., (2001) that diuron at 2 WAS and pendimethalin at 1.2 kg a.i./ha reduced sesame plant stands by 8 to 98 %.

The timing of pre-emergence herbicides diuron and metalochlor at 3 days before sowing (DBS) and 0 days after sowing (DAS) in both years did not result in any significant ($p<0.01$) phytotoxicity effect on esame. However, when these herbicides were applied at 2 DAS in both years, they had a highly significant phytotoxic effect on the sesame at all timings (3, 6, and 9 WAS). Among all the treatments applied in the experiment, the timing of 3 WAS in 2022 for both diuron and Metalachlor had the highest mean phytotoxicity on sesame.

Table 3: Effect of sowing methods and timing of pre-emergency herbicide application on sesame weed dry matter at 3WAS and 6 WAS at 2021 and 2022 raining seasons

	WEED DRY MATTER					
	3WAS			6WAS		
	2021	2022	Mean	2021	2022	Mean
Treatment						
Sowing Method (S)						
Drilling	10.09	7.39	8.74*	18.00	12.20	15.10^{NS}
Broadcasting	11.43	8.42	4.01*	17.32	12.80	15.06^{NS}
SE ±	1.12	0.68	0.44	1.52	1.03	1.28
LSD	4.83	2.93^{NS}	3.88	6.55	4.44	2.75
Timing of HB App.(T)						
Diuron 3DAS	3.28	4.25	3.77*	4.82	6.00	5.41*^{NS}
Diuron 0DAS	6.65	5.38	6.12^{NS}	6.30	12.30	9.30^{NS}
Diuron 2DAS	11.58	7.37	9.48^{NS}	10.75	10.70	10.73^{NS}*
Metolachlor 3DBS	11.02	8.17	9.60 ^{NS}	20.45	13.00	16.73^{NS}
Metolachlor 0DAS	9.40	5.08	7.24 ^{NS}	13.45	13.00	13.23*^{NS}
Metolachlor 2DAS	5.67	4.67	5.17 ^{NS}	29.43	17.2.	23.32^{NS}*
HW 3& 6 WAS	17.35	7.27	12.31^{NS}	26.17	12.80	19.49 ^{NS}
WC	21.10	21.03	21.07^{NS}	29.92	14.60	22.26 ^{NS}
SE ±	2.21	2.38	2.30	3.00	4.77	3.89
LSD	4.53	4.88	4.71	6.14	9.78	7.96
Interaction S x T	NS	NS	NS	NS	NS	

Means in columns followed by the same symbol (*) within the same treatment group are statistically different at either significant at 1% and 5% level of probability; Ns = not significant; WAS=weeks after sowing, WC = weedy check

The dry matter production of weeds was greatly influenced by the dates on which they were sown. During the two-year trial period, the average mean of the combined means for both drilling and broadcasting at 3 WAS showed that the drilling produced the highest weed dry matter, (8.74). This could be attributed to the high population of dormant seeds in the soil that had escaped the first dose of pre-emergence herbicide applied to both planting methods.

Table 4: Effect of sowing methods and timing of pre-emergence herbicide application on sesame yield at 2021 and 2022 raining seasons

	Yield		
Treatment	**2021**	**2022**	**Mean**
Sowing methods(S)			
Drilling	262.7	272.4	535.1
Broadcasting	235.0	225.4	230.2
SE±	8.15	7.50	
LSD	35.05	32.25	33.65
Timing of Hb App(T)			
Diuron 3 DBS	296.2	303.7	283.0
Diuron O DAS	265.1	272.8	269.0

Diuron 2 DAS	221.7	203.3	212.5
Metolachlor 3 DBS	311.4	316.6	314.0
Metolachlor O DAS	283.2	286.4	284.8
Metolachlor 2DAS	191.6	174.3	183.0
HW 3 and 6 WAS	304.6	317.2	310.9
WC	117.0	116.9	117.0
SE±	10.18	13.82	12.0
LSD	20.86	28.30	24,58
Interaction S x T	*	*	

Means in columns followed by the same symbol (*) within the same treatment group are statistically different at either significant at 1% and 5% level of probability; Ns = not significant; WAS=weeks after sowing WC = weedy check

Table 4, results indicated that pre-emergence herbicides had a significant effect on grain yield in both years. Observations of sowing methods in 2021 and 2022 indicated that the drilling method resulted in the highest sesame yield, compared to the broadcasting method. This finding is consistent with Benard and Leap, (2012), which suggested that drilling and cover cropping have greater uniformity and faster emergence, leading to a higher yield and a better ability to suppress weeds. This also agrees with UIES, (2005), that broadcasted seeds generally produce lower yields than drill-seeded crops. A thinner stand can be attributed to poor seed-to-soil contact, deeply covered, and more competitive weeds.

Sesame yield was higher ($p<0.05$), when treated with Metolachlor at 3 DBS, followed by Diuron at 3 DBS. Metolachlor at 3 DBS produced the highest yield ($p<0.05$), and Diuron at 2 DAS respectively produced the highest yield. The low phytotoxicity of Metolachlor at 3 DBS and its efficacy in weed control throughout the season prevented competition for growth resources, leading to better growth and higher yield.

The application of Diuron at 3 DBS has demonstrated the capacity to generate a high yield. This can be attributed to the low phytotoxicity of this herbicide on the crop at 9 weeks after sowing (WAS), in addition to its ability to effectively suppress both weeds hence, dry matter during the entire season. As a result, this prevents weed competition and enables the crop to access more growth resources, leading to a significant increase in yield.

The herbicides previously mentioned exhibited noticeably greater yields at their designated rates. This could be attributed to their minimal or non-existent phytotoxicity to sesame, as well as their efficacy in targeting weeds. This allowed for optimal absorption of nutrients and moisture, resulting in improved growth and a higher yield. These results are consistent with the discoveries made by Grichar et al. (2001), who observed that the use of 3.36 kg a.i./ha metolachlor resulted in an 80% increase in yield compared to the untreated control.

CONCLUSION

From this research, it can be recommended that adopting the drilling method in combination with pre-emergence herbicide application before sowing gave better weed control efficiency using Metolachlor 3 DBS, Overall, this study suggests that pre-emergence herbicides should be applied before sowing when sesame crop is grown using drilling method for higher grain yield and weed control efficiency.

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EFFECT OF COW MANURE AND VARIETIES OF SESAME ON SELECTED GROWTH AND YIELD OF SESAME AT LAFIA-NASARAWA STATE

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ABSTRACT
An experiment was carried out to determine the effect of cow manure on growth and yield of sesame varieties (Sesamum indicum L.*) at the Teaching and Research Farm, Faculty of Agriculture, Shabu–Lafia Campus, Nasarawa State University, Keffi-Nasarawa State, during the 2018 and 2019 cropping seasons. The experimental design was a Randomized Complete Block Design, laid out as a factorial consisting of six varieties (NCRIBEN 01M, NCRIBEN02M, NCRIBEN 03M, NCRIBEN 04E, NCRIBEN 05E and E-8) and four level of cow manure (0,5,10 and 15 t/ha). Data was collected on selected growth parameters (plant height, number of branches and number of leaves). The results showed that varieties differed significantly across all parameters. The application of 15 kgha^{-1} of cow manure gave significantly taller ($p<0.05$), plants, higher number of leaves and number of branches. Flowering was significantly ($p<0.05$), delayed in the control study. Also, it was observed that the use of variety E-8 in combination with application of 15 kgha^{-1} of cow manure gave higher growth and yield and is recommended for production of sesame Nasarawa State*.
Keywords: Cow manure; *Sesamum indicum L.*

INTRODUCTION
Sesame *(Sesamum indicum* L.*)* is an oil crop belonging to the family Pedaliaceae. Is an important crop to Nigerian agriculture because of its extensive cultivation. It is grown in tropical and subtropical regions of Africa, Asia, Latin America, India. Sesame oil is reputed to be the king of all vegetable oils, (Shahab-U-Din *et al.*, 2015; Nigerian Export Promotion Council -NEPC, 2010). The major producing States in Nigeria are Nasarawa, Jigawa, Benue, Yobe, Kano, Katsina, Gombe, Taraba and Adamawa. World production in 2020 was 6.01600 MT grown worldwide on 11.743,000 ha with an average yield of 512 kg ha^{-1} , with Asia and Africa producing nearly 97 % of the world supply of sesame, (Food and Agriculture Organization Statistical Database FAOSTAT, 2020).

Naturland, (2002) identified some local varieties cultivated within the tropics and subtropics as the black, white, brown colour and KS-S6.

Organic materials are major sources of organic matter and plant nutrients including cow manure. Their application into soil are reputed to improve soil physical attributes (soil structure, soil aggregate stability, water holding capacity, drainage, aeration, root penetration) and chemical attributes (nutrients content and composition and pH). The application of organic manure would most likely improve growth, yields and seed quality (Craswell *et al., (*2002). Duhoon *et al., (*2015), reports that where chemical fertilizers are available, excessive usage may increase pollution, decrease soil productivity and lead to nutrient imbalance.

The continuous cultivation, coupled up with increased population and industrial development, cultivable lands are becoming small for production leading to losses in fertility. The cost of inorganic fertilizer which many households may not afford. Cow manure is commonly available and affordable. This study therefore seeks to assess the growth and yield of sesame varieties under varying cow manure rates.

MATERIALS AND METHOD
Experimental Site
An experiment was carried out to determine the effect of cow manure on growth and yield of sesame varieties (Sesamum indicum L.) at the Teaching and Research Farm, Faculty of Agriculture, Shabu–Lafia Campus, Nasarawa State University, Keffi-Nasarawa State, during the 2018 and 2019 cropping seasons. The

experimental design was a Randomized Complete Block Design, laid out as a factorial consisting of six varieties (NCRIBEN 01M, NCRIBEN02M, NCRIBEN 03M, NCRIBEN 04E, NCRIBEN 05E and E-8) and four level of cow manure (0,5,10 and 15 t/ha). Data was collected on selected growth parameters (plant height, number of branches and number of leaves). The gross plot size was 3 m x 3 m (9 m^2) and net plot size was 3 m x 1.5 m (4.5 m^2)

Land preparations and manure incorporation.

The field was cleared, and pegged to layout. Ridges were constructed manually at 75 cm between rows. A 1 m gap was left as alleyways between plots, while 1 m was maintained between replicates. The four levels of cow manure were applied by opening the top ridge and covering up and allowed to decomposed two weeks before seed sowing.

Sowing

A pinch of sesame seed was sown at 10 cm spacing on ridges and covered thinly with soil and later thinned to three plants per stand at 3 weeks after sowing (WAS).

Crop protection/weed control

Hoe weeding was carried out at 3, 6 and 9 WAS to reduce competition for nutrients.

Harvesting,

The crop was due for harvest when the leaves and stem turned yellowish. The mature plants were cut at the base using sickles and allowed to dry. The sacks in which harvested plants were put at harvest were gently beaten with sticks to ensure pod breakage and seed removal from capsules. Winnowing was done to separate good seeds from chaff.

Data Collection

The randomly tagged plants in each plot were used for data collection during the growth and assessment at 4, 6, 8, 10 and 12 WAS were assessed at harvest and post-harvest.

Plant Height (cm)

The height of the three tagged plants in each plot were measured from ground level to growing tip of the main stem using meter-rule and means recorded.

Number of Branches

The number of branches were counted from the three tagged plant and means recorded.

Number of Leaves per Plant

The number of leaves per plant were counted from the tagged plants and means recorded.

Statistical Analysis

Data was subjected to ANOVA using F-test to determine significance of treatments (Snedecor and Cochran, 1967). Means were separated using Duncan Multiple Range Test (DMRT) at 0.05 level of significance. SAS was used for analysis.

RESULTS AND DISCUSSION

Effects of Cow Manure and Variety on Plant Height of Sesame Plant

At 4 and 12 WAP in 2018, application of 10 to 15 kg cm/ha $^{-1}$ did not influence growth parameters, ($p<0.05$), but was significantly higher ($p<0.05$), at 5 kg cm/ha $^{-1}$, while in 2019, at 4 WAP there is no significant difference on plant height among the treatments (Table 1). In both years, at 6, 8, 10 and 12 WAP in 2019, each increase in application rate of cow manure significantly increased ($p<0.05$), height of sesame. Similarly, at 4 WAP, in both years NCRIBE04E variety produced significantly higher ($p<0.05$), plant height as compared to other varieties. In both years, at 6 and 8 WAP NCRIBEN 05E produced significantly higher ($p<0.05$), plant than other varieties. At 10 and 12 WAP, in 2018 and 2019 cropping seasons, E-8 recorded significantly higher ($p<0.05$), plant height than other varieties in this study.

Table 1: Effect of Cow Manure and Variety on the Plant Height of Sesame at 4, 6, 8, 10 and 12 WAS in Lafia during the 2018 and 2019 Cropping Seasons.

		2018 WAS		plant height				2019 WAS		
Treatment	**4**	**6**	**8**	**10**	**12**	**4**	**6**	**8**	**10**	**12**
Cow manure (C) (kg ha^{-1})										
0	8.0^{b}	25.6^{d}	53.1^{d}	75.6^{d}	91.5^{b}	9.1^{a}	26.8^{d}	54.5^{d}	76.9^{d}	91.3^{d}
5	8.2^{b}	29.9^{c}	57.0^{c}	79.3^{c}	997.4^{b}	9.0^{a}	32.3^{c}	59.4^{c}	80.3^{c}	98.5^{c}
10	9.2^{a}	35.5^{b}	66.4^{b}	55.0^{b}	106.7^{a}	9.7^{a}	37.3^{b}	67.9^{b}	85.0^{b}	106.3^{c}
15	8.7^{ab}	40.5^{a}	67.7^{a}	88.3^{a}	107.4^{a}	8.8^{a}	42.8^{a}	71.1^{a}	90.6^{a}	115.3^{a}
SE ±	0.26	0.44	0.44	0.23	2.55	0.36	0.69	0.32	0.35	0.19
Variety (V)										
NCRIBEN 01M	87.7^{bc}	28.2^{d}	59.9^{c}	75.6^{e}	98.4^{bc}	9.3^{ab}	30.5^{d}	61.1^{c}	76.7^{e}	98.8^{e}
NCRIBEN 02M	7.4^{d}	28.2^{d}	62.7^{d}	80.5^{c}	103.7^{ab}	8.3b	29.5^{d}	63.8^{c}	81.5^{c}	104.2^{b}

NCRIBEN 03M	8.6^{bc}	34.7^{b}	58.5^{c}	77.2^{d}	92.0^{c}	8.7c	36.1^{bc}	60.4^{c}	78.2^{d}	100.9^{d}
NCRIBEN 04E	9.7^{a}	32.7^{c}	56.2^{d}	81.2^{c}	100.6^{bc}	10.3a	34.9c	58.8^{d}	82.1^{c}	101.1^{d}
NCRIBEN 05E	9.9^{ab}	37.5^{a}	67.5^{a}	87.5^{b}	101.3^{abc}	9.2^{ab}	39.5^{a}	70.5^{a}	88.4^{b}	102.1^{c}
E-8	7.9^{cd}	36.1^{ab}	62.8^{b}	90.3^{a}	108.9^{a}	9.1^{ab}	38.4^{ab}	64.7^{b}	92.1^{a}	110.0^{a}
SE ±	0.31	0.53	0.47	0.28	3.13	0.44	0.85	0.39	6.44	0.23
Interaction										
C X V	NS	NS	NS	NS	**	NS	NS	NS	NS	**

Means of different letter(s) in each column of treatment group are significant at 5 % level of significance.
NS = Not significant
** = Significant at 5% level of significance

Table 2: Interaction between Cow Manure and Variety on Plant helight at 12 WAS of Sesame in Lafia during the 2018 and 2019 Cropping Seasons.

	2018				2019			
	Cow manure kg ha^{-1}				Cow manure kg ha^{-1}			
Variety	**0**	**5**	**10**	**15**	**0**	**5**	**10**	**15**
NCRIBEN 01M	92.4^{d}	94.9^{d}	99.4^{c}	107.0^{b}	90.3^{f}	95.8^{e}	100.8^{d}	108.5^{c}
NCRIBEN 02M	94.8^{d}	99.0^{c}	106.1^{b}	109.7^{b}	94.1^{e}	100.3^{d}	106.6^{c}	115.8^{b}
NCRIBEN 03M	89.5^{e}	94.9^{d}	112.0^{b}	71.6^{f}	90.1^{f}	96.2^{d}	104.5^{c}	112.7^{b}
NCRIBEN 04E	87.4^{e}	94.4^{d}	103.3^{c}	115.4^{a}	87.9^{f}	95.5^{e}	104.5^{c}	116.3^{a}
NCRIBEN 05E	88.2^{e}	96.3^{d}	104.4^{c}	116.4^{a}	88.5^{f}	97.3^{d}	105.1^{c}	117.4^{a}
E-8	96.4^{d}	105.0^{b}	115.0^{a}	119.3^{a}	96.9^{d}	106.0^{c}	116.4^{a}	120.9^{a}
SE ±			6.25				4.53	

Means of the same letter(s) within the same treatment group are statistically the same

There were significant ($p<0.05$), interactions were observed between cow manure and variety on plant height at 12 WAS in both years (Table 2). E-8 variety produced the tallest ($p<0.05$), plant height at 15 kg/ha of cow manure.

Effects of Cow Manure and Variety on the Number of Branches of Sesame

The results obtained showed that treatments significantly affected ($p<0.05$), number of branches among (Table 3). In 2018 at 4 WAP, application of cow manure. At 6 WAP in 2018, at 4, 8, 10 and 12 WAP in 2019, each increase in the rate of cow manure applied significantly increased ($p<0.05$), the number of branches, while In 2018, at 8, 10 and 12 WAP, 10 kg /ha and 15 kg /ha of cow manure gave statistically similar ($p<0.05$), number of branches. Similarly, at all sampling periods, in both years, E-8 variety produced significantly higher number of branches than other varieties. There were significant interactions between cow manure and variety on number of branches at 12 WAS in both years (Table 4). The E-8 variety produced the highest number of branches at the application of 15kg/ha of cow manure than other varieties.

The result showed that number of leaves among treatment was significantly different ($p<0.05$), (Table 5). In 2018 and 2019, at 10 and 12 WAP, each increase in the rate of applied cow manure significantly increased number of leaves. Similarly, at 4 WAP in both years, NCRIBEN 04 E variety produced significantly higher ($p<0.05$), number of leaves compared to other varieties, while at 6 WAP in both years variety NCRIBEN 03M produced significantly higher($p<0.05$), number of leaves compared to other varieties. Also, at 8 WAP in both cropping seasons NCRIBEN 04E, NCRIBEN 05 E and E8 recorded significantly higher ($p<0.05$), number of leaves. There were significant interactions ($p<0.05$), between cow manure and variety on number of leaves at 12 WAS in both years (Table 6). The E-8 variety produced the highest number of leaves at 15kg/ha of cow manure.

From the results obtained, the variations in growth and yield of sesame at 15 kg/ha^{-1} of cow manure. This could be attributed to the ability of manure to supply nutrient gradually, but steadily to support crop which growth and hence, high yield (Aliyu, 2003; Annon, 2007). The higher plant high ,number of branches, and number of leaves of sesame than the control supported collaborates Ashri, (2007), Elnaim *et al.*, (2010) and Tefera (2016), especially as observed in E-8 variety. Kolo and Duniya (2006) also reported that E-8 variety significantly outperforms other varieties. Haruna *et al.* (2011) also reported that sesame variety E-8 will produce higher plant height, number of branches and number of leaves.

Table 3: Effect of cow manure and variety on the number of branches of sesame at 4, 6, 8, 10 and 12 WAS in Lafia during the 2018 and 2019 cropping seasons

	2018			Number of branches		2019				
			WAS					WAS		
Treatment	**4**	**6**	**8**	**10**	**12**	**4**	**6**	**8**	**10**	**12**
Cow manure (C) (kg ha^{-1})										
0	0.6^{a}	6.4^{d}	9.1^{c}	9.1^{c}	9.1^{c}	0.9^{b}	7.4^{c}	10.1^{d}	10.1^{d}	10.1^{d}

5	0.8^{a}	7.3^{c}	10.2b	10.2^{b}	10.2^{b}	1.2^{b}	7.5^{c}	11.5^{c}	11.5^{c}	11.5^{c}
10	0.8^{a}	8.7^{b}	12.1^{a}	12.1^{a}	11.1^{a}	1.3^{b}	1.6^{b}	12.9^{b}	12.8^{b}	12.8^{b}
15	1.3^{a}	10.0^{a}	12.8^{a}	12.8^{a}	12.8^{a}	2.4^{a}	10.9^{a}	14.2^{a}	14.2^{a}	14.2^{a}
SE ±	0.29	0.26	0.28	0.28	0.28	0.32	0.43	0.26	0.26	0.26
Variety (V)										
NCRIBEN 01M	1.0^{ab}	7.1^{b}	9.4^{d}	9.4^{d}	9.4^{d}	1.9^{a}	7.9^{bc}	9.9^{d}	9.9^{d}	9.9^{d}
NCRIBEN 02M	0.33^{b}	8.3^{a}	11.5^{b}	11.5^{b}	11.5^{b}	0.3^{b}	8.9^{abc}	12.3^{b}c	12.3^{bc}	12.3^{bc}
NCRIBEN 03M	0.33^{b}	7.2^{b}	12.0^{ab}	12.0^{ab}	12.0^{ab}	0.4^{b}	7.7^{c}	12.9^{b}	12.9^{b}	12.9^{b}
NCRIBEN 04E	1.5^{a}	8.6^{a}	10.5^{c}	10.5^{c}	10.5^{c}	1.9^{a}	9.1^{abc}	12.1^{bc}	12.0^{bc}	12.0^{bc}
NCRIBEN 05E	0.9^{ab}	8.3^{a}	10.4^{cd}	10.4^{cd}	10.4^{cd}	1.9^{a}	9.4^{ab}	11.7^{c}	11.7^{c}	11.7^{c}
E-8	1.2^{ab}	9.0^{a}	12.8^{a}	12.8^{a}	12.8^{a}	2.2^{a}	10.1^{a}	14.0^{a}	14.0^{a}	14.0^{a}
SE ±	0.36	0.32	0.36	0.36	0.36	0.39	0.52	0.32	0.32	0.32
Interaction										
C XV	NS	NS	NS	NS	**	NS	NS	NS	NS	**

Means of different letter(s) in each column of treatment group are significant at 5% level of significance.
NS = Not significant
** = Significant at 5% level of significance

Table 4: Interaction between cow manure and variety on number of branches at 12 WAS of sesame in Lafia during the 2018 and 2019 cropping season.

	2018				2019			
	Cow manure kg ha^{-1}				Cow manure kg ha^{-1}			
Variety	**0**	**5**	**10**	**15**	**0**	**5**	**10**	**15**
NCRIBEN 01M	7.2^{h}	8.6^{g}	11.6^{d}	10.2^{e}	7.9^{i}	10.2^{g}	11.3^{f}	10.2^{g}
NCRIBEN 02M	9.6^{f}	10.7^{e}	12.4^{c}	13.1^{c}	10.5^{g}	11.6^{e}	13.4^{c}	13.8^{c}
NCRIBEN 03M	10.2^{e}	11.2^{d}	12.6^{c}	13.9^{b}	11.2^{f}	12.3^{e}	13.3^{d}	15.1^{b}
NCRIBEN 04E	8.4^{g}	9.1^{f}	12.5^{c}	11.8^{d}	10.0^{h}	11.2^{f}	12.7^{d}	14.1^{c}
NCRIBEN 05E	9.4^{f}	9.5^{f}	9.6^{f}	12.8^{c}	10.0^{h}	11.2^{f}	10.5^{g}	15.1^{b}
E-8	9.4^{f}	9.5^{f}	9.6^{f}	15.1^{a}	10.0^{h}	11.2^{f}	10.5^{g}	17.0^{a}
SE ±			0.68				0.63	

Means of the same letter(s) within the same treatment group are statistically the same at 5% level of significance.

Table 5: Effect of cow manure and variety on the number of leaves of sesame at 4, 6, 8, 10 and 12 WAS in Lafia during the 2018 and 2019 cropping seasons

	2018		Number of leaves			2019				
		WAS						WAS		
Treatment	**4**	**6**	**8**	**10**	**12**	**4**	**6**	**8**	**10**	**12**
Cow manure (kg ha^{-1})										
0	6.9^{a}	9.9^{c}	18.5^{c}	27.9^{d}	35.5^{d}	7.1^{bc}	10.5^{c}	19.2^{c}	29.0^{d}	36.8^{d}
5	6.6^{a}	11.3^{b}	21.0^{b}	31.8^{c}	39.5^{c}	7.2^{bc}	12.1^{bc}	22.1^{b}	33.1^{c}	40.5^{c}
10	6.8^{a}	12.9^{a}	28.4^{a}	37.5^{b}	46.2^{b}	8.0^{a}	13.6^{a}	29.2^{a}	38.6^{b}	47.6^{b}
15	7.0^{a}	12.0^{a}	27.1^{a}	42.5^{a}	55.2^{a}	8.2^{a}	13.2^{a}	28.6^{ab}	43.7^{a}	56.3^{a}
SE ±	0.15	0.32	0.53	0.29	0.31	0.14	0.26	0.43	0.27	0.29
Variety										
NCRIBEN 01M	6.5^{bc}	10.4^{c}	20.9^{c}	30.3^{d}	43.0^{b}	7.0^{bc}	11.1^{c}	21.2^{cd}	31.4^{d}	44.1^{c}
NCRIBEN 02M	7.0^{ab}	11.9^{b}	21.9^{abc}	38.0^{a}	45.5^{a}	8.2^{ab}	12.4^{b}	22.3^{c}	39.2^{a}	46.5^{a}
NCRIBEN 03M	6.9^{ab}	13.2^{a}	23.2^{ab}	31.5^{c}	44.7^{a}	7.6^{b}	14.3^{a}	24.1^{b}	32.6^{c}	46.6^{a}
NCRIBEN 04E	7.3^{a}	11.5^{bc}	24.2^{a}	33.6^{b}	44.6^{b}	8.8^{a}	12.2^{bc}	25.2^{a}	34.5^{b}	45.6^{b}
NCRIBEN 05E	6.3^{c}	11.3^{bc}	24.9^{a}	38.5^{a}	41.5^{c}	7.1^{bc}	12.1^{bc}	25.8^{a}	39.4^{a}	11.7^{c}
E-8	6.9^{abc}	11.0^{bc}	24.4^{a}	37.5^{a}	45.4^{a}	7.6^{b}	12.0^{bc}	25.7^{a}	39.0^{a}	46.5^{a}
SE ±	0.19	0.39	0.65	0.36	0.38	0.17	0.40	0.58	0.34	0.36
Interaction										
CXV	NS	NS	NS	NS	**	NS	NS	NS	NS	**

Means of different letter(s) in each column of treatment group are significant at 5% level of significance.
NS = Not significant
** = Significant at 5% level of significance

Table 6: Interaction between cow manure and variety on number of leaves at 12 WAS of sesame in Lafia during the 2018 and 2019 cropping season.

	2018				2019			
	Cow manure kg ha^{-1}				Cow manure kg ha^{-1}			
Variety	**0**	**5**	**10**	**15**	**0**	**5**	**10**	**15**
NCRIBEN 01M	35.1^{jk}	39.4^{i}	45.1^{f}	52.4^{c}	36.4^{k}	41.2^{hi}	46.3^{f}	52.9^{d}
NCRIBEN 02M	36.4^{j}	41.1^{gh}	49.1^{d}	55.6^{b}	37.2^{jk}	43.5^{g}	50.3^{e}	56.8^{b}
NCRIBEN 03M	35.4^{jk}	40.9^{h}	48.1^{de}	54.4^{bc}	36.1^{k}	42.0^{h}	49.3^{ef}	54.8^{c}
NCRIBEN 04E	36.2^{j}	39.4^{i}	45.3^{f}	57.4^{ab}	37.0^{jk}	40.6^{i}	46.3^{f}	58.7^{ab}
NCRIBEN 05E	33.7^{k}	37.2^{j}	42.2^{g}	52.8^{c}	34.7^{l}	38.5^{j}	44.0^{g}	53.1^{d}
E-8	36.2^{j}	39.2^{i}	47.4^{e}	58.7^{a}	37.6^{jk}	40.3^{i}	49.5^{ef}	59.2^{a}
SE ±			0.76				0.54	

Means of the same letter(s) within the same treatment group are statistically the same at 5% level of significance.

CONCLUSION

From the results of this study, it can be concluded that both growth and of sesame were better following the application of 15 kg ha^{-1}of cow manure with variety E-8 out-performing all other varieties. Using cow manure at 15 kg/ha^{-1} with E-8 variety of sesame are therefore, recommended for higher yields.

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EFFECTS OF INTRA–ROW SPACING AND POTASSIUM FERTILIZER ON NUMBER OF BRANCHES AND TUBER YIELD OF POTATO (*SOLANUM TUBEROSUM* L.) VARIETIES IN THE NORTHERN GUINEA SAVANNA-NIGERIA

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ABSTRACT
A field experiment was conducted during 2016 and 2017 wet seasons at the experimental farm of National Root Crops Research Institute, Umudike, under the Potato Program, Kuru and at Teaching and Experimental Farm of Plateau State University, Bokkos-Jos Plateau Stae. The experiment studied growth and yield of potato (Solanum tuberosum L.) varieties as influenced by intra–row spacing and potassium fertilizer in the Northern Guinea Savanna Zone, Nigeria. The experimental design was a Randomized Complete Block Design, laid out as a split plot and replicated three times The treatments consisted of three; potato varieties (Zafira, Caruso and Connect), intra–row spacings (20, 30 and 40 cm) and potassium (K) rates (0, 40 and 60 kg k_2O ha^{-1}). Potassium and intra-row spacing were the main plots, while variety was the sub plots. The result revealed that application of 60 kg K_2O ha^{-1} enhanced ($p<0.05$), crop growth and yield parameters measured. Results also showed that variety Connect, gave better growth ($p<0.05$), in terms of number of branches and total tuber yield. At Bokkos, number of branches had highest ($p<0.05$), value at 40 cm intra–row spacing, while at Kuru, 30 cm intra - row spacing gave higher ($p<0.05$), number of branches and total tuber yield. Number of branches and total tuber yield over all, was highest ha^{-1} ($p<0.05$), at 60 kg k_2O ha^{-1}.with Connects planted at 40cm intra–row spacing at both locations. Therefore, Connect is recommended for the Northern Guinea Savana of Nigeria at 40 cm spacing.
Keywords: *Pottassium Fertilizer, Intra-row Spacing,*

INTRODUCTION
Potato (*Solanum tuberosum* L.) belongs to the family *Solanaceae.* The word potato may refer either to the plant itself or the edible tuber (FAO, 2021). Plant nutrition is important especially on the Jos Plateau, where continuous cropping and mining has greatly depleted the soil of the major nutrients (N, P and K), (Okonkwo *et al.*, 1995). Potato requires a deep well–drained sandy or silt loam soils with a soil pH between 5.5 to 6.5 and low temperatures (15–20^0). The ideal soil temperature for planting is 13–16^0C and 21°C for growth (AHDB, 2015). The problem of spacing is common on farmers field, therefore, resulting in fewer stands per unit area or overcrowding resulting in competition and subsequently, poor yields. Low potato yields from farmers' fields on the Jos Plateau is attrubuted to inability of farmers to adequately provide essential production inputs most especially the inorganic fertilizer, which are scarce, costly and beyond the reach of resource-poor farmer and are sometimes adulterated. It is therefore, the objectives are therefore, to determine growth and yield of potato varieties in response to intra–row spacing and rates of potassium fertilizer on the Jos Plateau. Okonkwo *et al*. (1995), reported that 30 cm intra-row spacing is the recommended intra-row spacing for rain fed potato production. Although generally, farmers use wider spacings of 50–60 cm and in most cases, grow the crop as an intercrop with maize. Therefore, it has become imperative to come up with recommendations for intra-row spacing that will enhance potato growth, development and tuber yield per unit area..

MATERIALS AND METHODS
Field experiment was carried out during the wet seasons of 2016 and repeated in 2017 at Kuru, with an annual rainfall of 1400 mm and at Plateau State University Farm, Bokkos with annual rainfall of 1386 mm in the Northern Guinea Savanna Zone-Nigeria. Ten soil samples within the experimental sites were randomly collected in both years at a depth of 0–30 cm using soil auger. The soil samples were bulked into composite sample, air dried, ground into powder and sieved using 2 mm mesh sieve and analyzed for physical and chemical properties.

The experiment studied growth and yield of potato (Solanum tuberosum L.) varieties as influenced by intra–row spacing and potassium fertilizer in the Northern Guinea Savanna Zone, Nigeria. The experimental design was a Randomized Complete Block Design, laid out as a split plot and replicated three times The treatments consisted of three; potato varieties (Zafira, Caruso and Connect), intra–row spacings (20, 30 and 40 cm) and potassium (K) rates (0, 40 and 60 kg k_2O ha^{-1}). Potassium and intra-row spacing were the main plots, while variety was the sub plots. The result revealed that application of 60 kg K_2O ha^{-1} enhanced ($p<0.05$), crop growth and yield parameters measured. Chemical weed control was done at planting using two pre-emergence herbicides (Alachlor at 1.92 kg a.i ha^{-1} and Atrazine powder), at the rate of 4 kg a.i ha^{-1} using CP-15 Knapsack sprayer at a pressure of 2.1 kg cm^2 and by manual hoe weeding at 4 and 8 weeks after planting (WAP). Earthen–up was done at 9 WAP. Pest and diseases were controlled by application of Ridomil at the rate of 2.5g and F–FORCE (mancozeb 2.0 g a.iha^{-1}), applied bi-weekly beginning at 2 WAP, done to prevent fungal disease attack. Bacterial wilt (*Rhalstonia Solanecearum* L.) was controlled by rogueing from 3 WAP to harvest. Potato tuber moth and rodents were controlled using Pestox 2.0g a.i ha^{-1} and rodenticide (Phostocin) 1.0g/ per plot respectively, at 4 WAP. Harvesting was done at 12 WAP when 95 % of the leaves turned yellow and senescence bagan, indicating maturity. Harvesting was done carefully by lifting out tubers with garden fork. Thereafter the tubers were hand-picked and weighed immediately using a portable weighing balance of 120 kg capacity. The weight in kg was recorded and later on converted to t ha^{-1}. All data were subjected to analysis of variance (ANOVA), using a General Linear Model in statistical Analysis System (SAS), package. significant means were separated using Duncan's Multiple Range Test, (DMRT) (Duncan 1955) at 5 % level of probability.

RESULTS AND DISCUSSION

Table 1 shows effects of intra-row spacing and potassium fertilizer on number of branches of potato varieties at 9 WAP at Bokkos and Kuru during 2016 and 2017 cropping seasons. At both locations, in both years variety Connect produced higher number ($p<0.05$), branches than the other two varieties, while Zafira in 2017 at kuru, produced the lesser ($p<0.05$), robust plants. This could be attributed to varietal response to environmental factors and treatments. Connect variety was most likely more responsive than other varieties. This is line with the report of Abong *et al.* (2010) who reported that, potato varieties responded significantly to intra-row spacing and fertilizer application through number of branches. The superiority of varieties Connects and Caruso over Zafira in terms of plant height implied better morphological differences which resulted in faster growth. At Bokkos, in 2016, 2017 and at Kuru in 2016, height of potato at 20 and 30 cm intra–row spacing were statistically similar ($p<0.05$), and taller than for 40 cm intra–row spacing. In 2017, at Kuru, 30 and 40cm intra-row spacing were also similar ($p<0.05$), and taller than 20 cm intra–row spacing. At Bokkos and Kuru, in 2016, increasing K rates from 0 to 40 and later to 60 kg K ha^{-1}. correspondingly increased plant height ($p<0.05$), while in 2017 at Kuru, height for 0 and 40 kg K ha^{-1}were statistically similar ($p<0.05$), and shorter than 60 kg K ha^{-1}. A similar trend was observed at Bokkos, in 2017, with potato heights in plots with 40 and 60 kg K ha^{-1} were statistically been similar ($p<0.05$), and taller than for 0 kg K ha^{-1}.

Table 2 shows effects of intra-row spacing and potassium fertilizer on total tuber yield of three potato varieties during the 2016 and 2017 wet seasons at Bokkos and Kuru. In 2016, at Bokkos Connect produced the highest ($p<0.05$), total tuber yield followed by Caruso, while Zafira had the least total tuber yield t ha^{-1}. However, in 2017 at Kuru, Zafira and Caruso were statistically similar ($p<0.05$), but lower in total tuber yield t ha^{-1} than Connect. Increasing intra-row spacing from 20 to 30 cm and further to 40 cm at both locations correspondingly increased total tuber yield ha^{-1}. Except in 2017 at Bokkos and Kuru, increasing K rates from 0 to 40 cm to 60 kg K_2O ha^{-1} correspondingly increased total tuber yield, but in 2017, at both locations, 40 and 60 kg K had similar ($p<0.05$), tuber yield ha^{-1} but higher than 0 kg K_2O ha^{-1}. Only the interaction of K fertilizer rates and variety on total tuber yield t ha^{-1} in 2016 at Bokkos and Kuru was significant ($p<0.05$). Larger LAI values were observed to result in greater assimilate production and hence, higher DM production and accumulation and subsequently total tuber yield.

Table 1: Effect of intra-row spacing and potassium fertilizer on number of branches per stand of three potato varieties during 2016, 2017 wet seasons at Bokkos and Kuru

Number of Branches/Stand at 9 WAP

	Bokkos			Kuru		
Treatments	**2016**	**2017**	**Combined**	**2016**	**2017**	**Combined**
Varieties (V)						
Zafira	4.10b	2.18c	3.14c	4.51b	4.39b	4.45b
Caruso	4.66b	2.43b	3.54b	4.83b	4.77b	4.80b

Connect	7.59a	2.77a	5.18a	6.50a	6.38a	6.44a
SE±	0.198	0.063	0.104	0.249	0.219	0.166
Spacings (S) cm						
20	4.52b	2.13b	3.33b	4.72b	4.53b	4.62c
30	5.81a	2.67a	4.24a	5.16b	5.22ab	5.19b
40	6.02a	2.58a	4.30a	5.97a	5.80a	5.88a
SE±	0.28b	0.064	0.143	0.219	0.235	0.156
Potassium (K) kg ha^{-1}						
0	5.54	2.49	4.02	5.18	5.16	5.16
40	5.35	2.50	3.93	5.24	4.93	5.09
60	5.46	2.39	3.93	5.45	5.45	5.45
SE±	0.286	0.064	0.143	0.219	0.235	0.156
Interaction						
K x S	NS	NS	NS	NS	NS	NS
K x V	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS
K x S x V	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within column are not significantly (p<0.05) different using DMRT; NS=Not significant (p<0.05); WAP=Week after Planting

Table 2: Effect of intra-row spacing and potassium fertilizer on total tuber yield of three potato varieties during 2016 and 2017 wet seasons at Bokkos and Kuru

	Total tuber yield (t ha^{-1})					
	Bokkos			Kuru		
Treatments	**2016**	**2017**	**Combined**	**2016**	**2017**	**Combined**
Varieties (V)						
Zafira	7.73c	4.70b	6.21b	7.70b	5.71b	6.71b
Caruso	9.61b	4.62b	7.11b	8.48b	6.00b	7.24b
Connect	31.39a	22.08a	26.73a	29.46a	24.85a	27.15a
SE±	0.591	0.407	0.359	0.511	0.587	0.536
Spacings (S) cm						
20	11.29c	6.63c	8.96c	10.95c	8.12c	9.54c
30	16.88b	9.98b	13.43b	15.37b	12.63b	14.00b
40	20.56a	14.80a	17.68a	19.32a	15.80a	17.56a
SE±	0.624	0.337	0.354	0.483	0.490	0.334
Potassium (K) kg ha^{-1}						
0	4.18c	4.70b	4.45c	3.92c	3.02c	3.47c
40	18.98b	21.62a	20.30b	17.42b	24.15a	20.78b
60	25.57a	22.08a	23.83a	24.30a	23.59a	23.95a

SE±	0.624	0.407	0.354	0.483	0.490	0.334
Interaction						
K x S	NS	NS	NS	NS	NS	NS
K x V	**	*	NS	**	NS	NS
S x V	NS	NS	NS	NS	NS	NS
K x S x V	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a column are not significantly ($p<0.05$) different using DMRT; NS=Not significant ($P<0.05$); * = Significant ($p<0.05$),

CONCLUSION

Based on the findings of this study, variety Connect is recommended for cultivation in the study locations based on its consistencies in terms of crop growth and yield. The use of 30 cm intra-raw spacing for potato production for Zafira and Caruso recommended as ideal for the two locations while 40 cm intra–raw spacing recommended for Connect. Application of 60 kg K_2O ha^{-1}

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Federal University of Lafia Nasarawa State

"LAFIA"

SUB-THEME 7:

Strategic Approaches to Crop Protection: Challenges and Opportunities

AN ASSESSMENT OF HEAVY METAL CONTENT IN SCENT LEAF (*OCIMUM GRATISSIMUM* L.) SOLD IN WARRI MARKETS, DELTA STATE, NIGERIA

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ABSTRACT
An assessment of the heavy metal content in scent leaf (O. gratissimum) sold in Warri market, Delta State was evaluated in Abraka, Delta State Nigeria. However, when the scent leaves containing heavy metals were compared with the control (Abraka markets) where there are no oil activities, significant increases were observed in the values obtained for scent leaves in the two markets for all the metals recorded viz: Pb, Cr, Zn, Mn, Cd and Fe. Although, the results fall within allowable values given by FAO/WHO, the metal values could constitute health risks to the people who consume them as they bio accumulate with time. Potential health hazard is eminent to consumers because of their non-biodegradability. It is recommended that a close monitoring of vegetables sold in Warri area should be carried out for heavy metal accumulation to avoid danger posed by them on plants, man and animals. Hence, environmental education at all levels is highly recommended.
Keywords: *Assessment, metal content, Ocimum gratissimum, Warri, Delta State.*

INTRODUCTION
Occimum gratissimum (Scent leaf, Clove basil or African Basil) (Family Lamiaceae, mint family) is one of the most commonly consumed leafy vegetables in Nigeria. This vegetable was said to have originated from India where it was first used as vegetables and medicine. It is a shrub found in the tropical and warm temperate areas. The leaves act as food additives, spice, highly nutritive and medicinal values because of the high aromatic and antioxidant content (Agogidi *et al*., 2014). It is used for the treatment of various diseases including respiratory tract infections, headaches, skin infections, pneumonia, tooth and gum, diarrhoea, fever as repellants for mosquitoes and other insects (Gill, 1992). It is an aromatic perennial herb characterized with much branching, glabrous or pubescent. It can be cultivated or in the wild with many varieties. It is rich in alkaloids, tannins, phytates, oligosaccharides and flavonoids. Other phytochemicals found in scent leaves include phenols, carotenoids, saponnines and minerals including potassium, calcium, iron and magnesium (Gill, 1992). Kurian (2010) noted that the oil from the leaves is antiseptic, antibacterial and antifungal in activity.

Leafy vegetables play important role in animals and human diets but can habour high metal contents based on where they are grown (Agbogidi, 2013; Agbogidi *et al*., 2013). Agbogidi (2013) established that heavy metals at low concentrations play essential roles in the body but at high concentrations, present health risk factors. Man's anthropogenic factors including oil exploration and exploitation activities have resulted in pollution of different types and magnitudes affecting man and his animals (Agbogidi and Eruotor, 2012). It is against this background that a study to assess the heavy metal contents of *O. gratissimum* sold in selected markets in Warri, the hub of oil industrial activities in Delta State in the Niger Delta region of Nigeria. Findings from this study will provide information on the metal status and types in *O. gratissimum* sold in Warri markets, assess the health risks as well as providing baseline information on the populace and compare their levels to Abraka where there are no oil activities to allow for adequate monitoring of metal contents on vegetables in the study area.

MATERIALS
Bitter leaves
Hydrochloric acid
Beakers
Distilled water
Filter paper

Metals e.g. Cd, Cr, Fe, Pb, Mn and Zn
Atomic Absorption Spectrophotometer

METHODS

Study location

The study was carried out in Abraka, Delta State, Nigeria. The study location is located between latitude 5° 45′ and 5° 5 0′ N and longitude 6° and 6° 15′ E. This area is defined by total annual rainfall of about 3.098mm with mean monthly rainfall ranging from 28.8mm. The soil temperature in this area is about 28^0C and soil pH ranging from 4.5-8. (Achuba and Ja-anni, 2018).

Sample collection

The scent leaves were purchased from two markets in Warri (Igbudu Main Market) and Abraka (Big Market).

Sample preparation

10g of the grounded powder samples were weighed and transferred into a labelled beaker and then 30ml of concentrated hydrochloric acid was added and left to stand for 30mins after which it was filtered. The filtrate was diluted with distilled water. The wet digested samples were analysed for heavy metals (Cd, Cr, Fe, Pb, Mn and Zn) using atomic Absorption Spectrophotometer following AOAC (2009).

Statistical analysis

Means and standard deviations of samples were calculated. One way analysis of variance (ANOVA) was conducted to determine the significant difference and the means were separated using Duncan's Multiple Range Test (DMRT) at P <0.05 using SAS (1996).

RESULTS AND DISCUSSIONS

Table 1 presents the results of the heavy metal analysis in *O. gratissimum* from Warri and Abraka markets relative to FAO/WHO allowable levels.

Table 1: Heavy metal content in scent leaf (mg/kg) sold in Abraka and Warri markets, Delta State, Nigeria.

Heavy metal profile (mg/kg)	Abraka market	Igbudu market, Warri	Warri main market	FAO/WHO levels
Lead (Pb)	0.01^b	0.03^a	0.04^a	0.3
Chromium (Cr)	0.07^b	0.10^a	0.15^a	2.3
Zinc (Zn)	0.06^a	0.09^a	0.10^a	99.4
Manganese (Mn)	0.05^c	0.07^b	1.09^a	500
Cadmium (Cd)	0.03^c	0.05^b	0.10^a	0.2
Iron (Fe)	0.06^b	0.10^a	0.13^a	425.5

*Means with same alphabet within same column (metal) are not significantly different using DMRT

From the Table1 above, when the scent leaves containing heavy metals were compared with the control (Abraka markets) where there are no oil activities, significant increases were observed in the values obtained for scent leaves in the two markets for all the metals recorded viz: Pb, Cr, Zn, Mn, Cd and Fe. The observed values obtained for the vegetable sold in Warri markets could be attributed to incidence of exploration and exploitation activities prevalent in Warri communities where the vegetable could have been grown. In same vein, Olusola *et al.* (2021) noted a buildup of heavy metals in the herbal plants sold in major urban markets in southwestern, Nigeria. Although, the results fall within allowable values given by FAO/WHO (2011), the metal values could constitute health risk to the people who consume them as they bio accumulate with time. Potential health hazard is eminent to consumers because of their non-biodegradability (Agbogidi and Enujeke, 2011). Metal toxicity could result in cardiac, neurological, immunological, reproductive and developmental issues among others

It is recommended that a close monitoring of vegetables sold in Warri area for heavy metal accumulation be carried out to avoid danger posed by them on plants, man and his animals. Hence, environmental education at all levels is highly recommended.

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BIOMARKERS OF OXIDATIVE STRESS OF THE CRUDE METHANOL LEAVES EXTRACT OF *BALANITES AEGYPTIACA* IN WISTAR RATS EXPOSED TO CHLORPYRIFOS

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ABSTRACT
Antioxidant activity of Balanites aegyptiaca in wistar rats exposed to chlorpyrifos was investigated in this study. About 1000 g of the powdered leaves of B. aegyptiaca was used for the extraction and methanol was the extraction medium while cold maceration was employed. Thirty wistar rats were randomly divided into six groups of five rats each. Rats in group I were neither treated nor exposed to chlorpyrifos. Rats in groups II to VI were exposed to chlorpyrifos at 2 mg/kg daily for seven days. Rats in groups; II, III and IV were treated with the extract at doses: 100, 300 and 500 mg/kg respectively. Rats in group V were treated with ascorbic acid (150 mg/kg). Rats in group VI were administered normal saline. All treatments were through oral route and were for 7 consecutive days. Seven days after, all rats were humanely euthanized by severing their jugular vein, and 5 ml of blood sample was collected from each rat and transferred into plain container devoid of anticoagulant for serum chemistry and antioxidant assay. There was significant ($p < 0.05$) increase in the mean values of liver enzymes; alanine amino transferase (ALT), aspartate amino transferase (AST) and alkaline phosphatase (ALP) in rats exposed to chlorpyrifos and treated with normal saline vis-à-vis other groups. Similarly, a significant ($p < 0.05$) reduction in the mean values of liver enzymes was recorded in rats treated with ascorbic acid vis-à-vis those treated with 500 mg/kg of crude methanol extract. A significant ($p < 0.05$) increase in the serum level of antioxidants enzymes; superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPx) were recorded in rats treated with B. aegyptiaca extract and ascorbic acid when compared to group VI. A significant ($p < 0.05$) increase in the mean values of antioxidants enzymes were recorded in group III, IV and V when compared to group II. In this study, methanol leaves extract of B. aegyptiaca largely exhibited ameliorative effect on the impact of chlorpyrifos.
Keywords: *Antioxidants, Balanites aegyptiaca, Chlorpyrifos, Liver enzyme, Methanol extract, Wistar rats.*

INTRODUCTION
Plants still remains the primary source of supply of many important drugs and minerals in the orthodox medicine today. Plants are being exploited for their active compound which is responsible for their biological function (Clark, 1996). *Balanites aegyptiaca* is commonly known as the Desert date, '*Aduwa*' in Hausa, '*enyi-ndi- mmuo*' in Igbo, and '*Tanni*' in Fulani (Ugwah *et al.*, 2016). It is a desert plant that is widely distributed in the arid zone of Nigeria. It is also found in other African countries like Senegal and Sudan, as well as in India (Chothani and Vaghasiya, 2011; Pandey *et al*., 2012). In Nigeria and Asia, it was reported to be used in a variety of folk medicines (Ugwah *et al.,* 2016).

Chlorpyrifos pesticide was reported in 1070s to have immunotoxic (Beckmen *et al*. 2003). Additionally, Beckmen *et al*. (2003) observed thymic atrophy and reductions in splenic germinal centers in rabbits following exposure to 1.5 mg/kg/day of chlorpyrifos. A number of organophosphate pesticides including chlorpyrifos, malathion, methylparathion and trichlorphon have shown immunotoxic properties (Casale *et al*., 1983) and suppression of primary humoral immune responses in laboratory studies. Noting the toxicity and efficacy of Chlorpyrifos; we embarked on this study to determine how the toxicity can be ameliorated.

MATERIALS AND METHODS
Study Location
The research was conducted in the Department of Animal Health and Production, Binyaminu Usman Polytechnic, Hadejia, Jigawa State, Nigeria.

Plant Collection and Identification

Fresh leaves of *B. egyptiaca* was collected around the main campus of Binyaminu Usman Polytechnic, Hadejia, Jigawa State. The plant was identified at the herbarium of the Department of Plant Biology, Bayero University Kano, Nigeria, with voucher number BUKHAN 359.

Extraction of the Plant Material

About 1000 g of the powdered leaves of *B. egyptiaca* was used for extraction and methanol was employed as the extraction medium and the technique deployed was cold maceration, using a 1-litre capacity separating funnel at room temperature for 48 hours. The initial extraction was done with 1.5 litre of methanol and the process was repeated twice using 750 litres of methanol in each extraction. The extracts obtained during the 3 phases of extraction were pooled together and concentrated under reduced pressure at 55 ºC, and then stored in a vacuum desiccator. Stock solution of the extract at concentration of 1 g/mL was prepared and stored at 4 ºC for pharmacological test.

Experimental Animals

Thirty wistar rats of either sex weighing between 200 and 220 grams were used. They were purchased from the Animal House, Department of Pharmacology and Toxicology, Faculty of Pharmaceutical Sciences, Bayero University Kano. The rats were housed in locally constructed cages at room temperature. Wood shavings were used as beddings in the cages and changed once every day. The rats were allowed free access to feed (commercially prepared) and water *ad-libitum*.

Experimental Treatments

Thirty wistar rats were randomly divided into six groups of five rats each. Rats in groups two to six were exposed to chlorpyrifos (2 mg/kg) daily and then treated as follows:

Group I - The rats in this group were neither exposed nor treated, therefore served as neutral control group.
Group II - Rats in this group received 100 mg/kg of *B. egyptiaca per os* for 7 days.
Group III - Rats in this group received 300 mg/kg of *B. egyptiaca per os* for 7 days.
Group IV - Rats in this group received 500 mg/kg of *B. egyptiaca per os* for 7 days.
Group V - Rats in this group received 150 mg/kg of Ascorbic acid *per os* for 7 days.
Group VI - Rats in this group received 5 mL/kg of normal saline *per os* for 7 days.

Serum Level of Liver Enzymes

Serum level of alanine amino transferase (ALT), aspartate amino trasferase (AST) and alkaline phosphatase (ALP) were determined using chemical auto-analyzer (Bayer® Clinical Chemistry Analyzer, Germany).

Antioxidant Enzymes

Determination of serum glutathione peroxidase (GPx) specific activity

Modified method of Paglia and Valentine (1967) was used to determine glutathione peroxidase (GPx) activity spectrophotometrically.

Determination of serum superoxide dismutase (SOD) specific activity

The specific activity of SOD was measured using the method described by Misra and Fridovich (1972) as modified by Sheridan-Rabideau (2001).

Determination of serum catalase (CAT) activity

The specific activity of catalase in the serum collected from each rat was determined using method described by Beers and Sizer (1952).

Statistical Analysis

The statistical analysis was carried out using SPSS software package, version 20. The results obtained are presented as mean ± standard deviation (M±SEM). A one-way analysis of variance (ANOVA) was used for the data analysis. Means with significant differences among the groups were detected using Bonferroni test at ($p \leq 0.05$).

RESULTS AND DISCUSSION

Liver enzymes (AST, ALT and ALP) reduced significantly ($p < 0.05$) in rats treated with crude methanolic leaf extracts of *B. aegyptiaca* in dose dependent manner. There was significant ($p < 0.05$) increase in the mean values of liver enzymes in rats exposed to chlorpyrifos and treated with normal saline when compared to the other groups. Similarly, a significant ($p < 0.05$) reduction in the mean values of liver enzymes was recorded in rats treated with ascorbic acid when compared to rats treated with 500 mg/kg of the crude methanolic leaf extracts of *B. aegyptiaca*. Awobode (2006), reported that liver enzymes were found in the serum and the level of their activity can be determined, and that depression or elevation of a particular enzyme indicates the presence of damage to specific tissue or organ. The elevated serum levels of AST and ALT may be attributed to hepatocellular damage as reported by Kobo (2012) and Gowda *et al*. (2005).

Table 1: Mean±SEM of liver enzymes in wistar rats exposed to chlorpyrifos and treated with crude methanolic leaf extract of *B. aegyptiaca*

	Treatment					
Test	**Neutral control**	***B. aegyptiaca* (100 mg/kg)**	***B. aegyptiaca* (300 mg/kg)**	***B. aegyptiaca* (500 mg/kg)**	**Ascorbic acid (150 mg/kg)**	**Chlorpyrifos (5 ml/kg)**
ALT(μ/L)	19.33±1.26	38.79±3.18	28.33±2.55	28.33±2.64	27.95±1.41	38.67±3.14
AST(μ/L)	49.83±3.10	75.53±4.17	56.33±4.57	54.36±3.90	53.33±3.57	80.20±5.14
ALP(μ/L)	80.69±2.64	103.40±5.88	87.72±6.16	85.00±5.22	83.27±5.70	108.50±7.71

Table 2: Mean±SEM of serum biomarkers of oxidative stress in wistar rats exposed to chlorpyrifos and treated with crude methanolic leaf extract of *B. aegyptiaca*

	Treatment					
Test	**Neutral control**	***B. aegyptiaca* (100 mg/kg)**	***B. aegyptiaca* (300 mg/kg)**	***B. aegyptiaca* (500 mg/kg)**	**Ascorbic acid (150 mg/kg)**	**Chlorpyrifos (5 ml/kg)**
SOD (μg/ml)	66.67±4.30	48.33±3.44	71.17±4.62	75.83±4.94	75.31±3.99	46.67±3.21
CAT(μg/ml)	72.67±3.47	46.50±3.09	73.50±6.29	75.33±2.36	77.17±3.79	48.33±3.98
GPx(μg/ml)	32.33±1.36	24.15±1.48	30.00±2.99	30.33±1.15	33.50±1.80	24.67±1.54

Superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPx) are enzymatic antioxidants that mop-up free radicals. A significant ($p < 0.05$) increase in the serum level of specific antioxidant enzymes were recorded in rats treated with *B. aegyptiaca* and ascorbic acid when compared to rats exposed to chlorpyrifos and those treated with normal saline. This could be due to the presence of flavonoids, saponins and alkaloids present in the plant and the finding of this research agrees with the report of Mandal *et al* (2007) in rats subjected to chemically induced hepatocarcinogenesis. The authors there reported the ability of flavonoids, saponins and alkaloids to stimulate the immune systems in an immunosuppressed animals.

CONCLUSION

Treating wistar rats exposed to chlorpyrifos with *B. aegyptiaca* leave extracts for seven consecutive days was noted to be ameliorative.

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EFFECT OF LAMBDA-CYHALOTHRIN INSECTICIDE SPRAY REGIMES APPLICATION ON THE GROWTH AND YIELD OF THREE COWPEA (*VIGNA UNGUICULATA* (L.) WALP.) VARIETIES

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ABSTRACT

This research work was conducted at the Teaching and Research Farm of the Faculty of Agriculture (Shabu-Lafia Campus {Latitude 08^{o}*,*33^{I}*N and Longitude* 08^{o}*,*32^{I}*E}), Nasarawa State University Keffi, to study the Effect of Lambda-cyhalothrin Insecticide Spray Regimes on the Growth and Yield of Three Cowpea (Vigna unguiculata(L.) Walp.) Varieties during 2018 and 2019 rainy seasons. There were 12 treatment combination which were replicated three times and laid out in a Randomized Complete Block Design (RCBD). Data were collected on growth parameters such as plant height, number of branches, number of leaves at 4, 6, 8 and 10 WAS; while yield parameters were taken on Total Biological Yield, Grain Yield, Haulms Weight per plot, Seed weight and percentage Harvest index. Analysis was done using GENSTAT software, version 13 and means were separated using Duncan Multiple Range Test on SPSS Version 22. The result of the experiment confirmed that cowpea Fuampea 2 produced significantly(P<0.05) higher growth and yield values than cowpea Fuampea 1 and the local(40 days) variety at all the respective sampling periods of 4, 6, 8 and 10 WAS . The yield parameters consequently showed that cowpea Faumpea 2 is better than other cowpea varieties.*

Keywords: *Contact insecticide, spray regimes, cowpea, Lambda-cyhalothrin, variety, Fuampea.*

INTRODUCTION

Cowpea(*Vigna unguiculata*(L.) Walp) is an annual crop grown for either its seeds or fodder, some varieties may be erect, climbing, prostrate and creeping. Prostrate cultivars can grow to about 80 cm while climbing varieties can grow up to 2 m and root systems of cowpea are well developed (Heuzé *etal*., 2015). A cowpea pod can contain 6-13 seeds that are usually kidney shaped, although the seeds become more spherical and more restricted within the pod(Sheahan, 2012). Cowpea is one of the most ancient human food sources and has probably been used as a crop plant since Neolithic times(Directorate of Plant Production (DPP) and Agricultural Resource Centre (ARC), 2011). Lack of archaeological evidence has resulted in contradicting views supporting Africa, Asia and South America as origin. Cowpea is grown as a main legume crop in Africa mostly in Egypt and Nigeria, South America, Colombia, Brazil, the USA, Mexico, Asia (China, Pakistan and Japan) and in Southeast Europe (Spain, Greece Italy, Portugal and Cyprus) (Antova*et al*., 2014). It has also been reported that out of 7.7 million hectares devoted to cowpea production worldwide, 6.1 million hectares (80%) are in the West African sub-region and Nigeria accounts for 4 million hectarage of cowpea production (Gerei *et al*., 2018). Nigeria is the world's leading cowpea producing country, followed by Brazil, other countries in West Africa, are Senegal, Ghana, Mali, Burkina Faso, Niger, and Cameroon (DPP and ARC, 2011).

Nigeria is regarded as the largest producer and consumer of cowpea in the world with an estimated 45% share of the global cowpea production and over 55% of the production in Africa (Alene *et al*., 2015). There is however, no single variety that has been found to be totally resistant to the numerous insect pests attacking the crop (Dzemo *et al*., 2010). Most varieties described as resistant are only resistant against one or a few insect pests which when used alone cannot provide satisfactory control against insect pests (Pulakkatu-Thodi *et al*., 2014; Abudulai *et al*., 2017). Cowpea varieties have been bred for a wide range of agronomic, grain quality with resistance or tolerance characteristics to abiotic and biotic stresses, but not much attention on developing varieties resistant to weed suppression (Ehlers *et al.*, 2002; Hall *et al*., 2003).

Substantial genetic diversity exists for growth habit characteristics and have excellent opportunity to develop varieties with higher weed suppressive ability as it was done in soybean [*Glycine max* (L.) Merr.] (Ehelers and Hall, 1997). Ewansiha and Tofa (2016) reported that yield potentials of IT98K-573- 2-1 cowpea variety was significantly higher in seed and fodder weights at 1155.3 kgha^{-1} and 6006.4 kgha^{-1} respectively than the other varieties tested (IT97K-499-35,IT98K-205, IT89KD-288 and IT99K-241-2). In another trial by Kirkhouse (2017). The crop has often been referred to as "the poor man's meat" due to the high levels of protein found in the seeds and leaves (Hamid *et al*., 2016). Cowpea seeds provide a rich source of proteins and calories, as well as minerals and vitamins (Gonçalves *et al*., 2016). A seed can consist of 23-25% protein, 50-67% carbohydrates, 8-9% moisture and it has very low fat content (3.99%) (Rangel *et al*., 2003).

Maruca vitrata, is a legume pod borer which has been investigated as a destructive pest of cowpea and other leguminous crops and are widely distributed throughout tropical and subtropical areas of the world where it causes extreme damages (Baoua *etal*., 2011). It is a major concerned cowpea pest in Africa and Southeast Asia whereby the larval stage causes the damage, attacking flower buds, flowers and young pods. Up to 80% cowpea yield losses are recorded (Dannon, 2011). Lambda-cyhalothrin 2.5EC (Kombat 2.5EC) is a non-systemic, contact stomach acting and repellant insecticide is mainly used for the control of wide spectrum of insect pests(Saro, 2018).Spraying contact or systemic insecticides three times on cowpea increases grain yield and economic net returns, (Kotu *et al*., 2017). Contact insecticide application has the ability to improve growth and yield of cowpea whose limiting factor of production has been insect pests destroying seed yield and quality to economic threshold (Tony *et al.,* 2014). Thus, notwithstanding, insecticide application remains the major option for insect pests control practice in cowpea in most African countries. This is so because of the spectacular results obtained in association with their application (Pulakkatu-Thodi *et al*., 2014; Abudulai *et al.*, 2017). However, despite concerted efforts by many institutions over the last two decades to develop varieties with resistance to the cowpea insect pest complex, resistant varieties are still unavailable to farmers. Thus, chemical control using synthetic insecticides therefore remains the most popular control option especially when these pests have exceeded the economic injury level (Jackai *et al*., 2001).

Significant reduction in pod pest infestation levels can be achieved by applying insecticides twice, each at flower budding and early podding respectively. This indicates that two insecticide spray regime at flowering and at podding could produce a good cowpea yield as same as the three to five spray regimes (Ajeigbe and Singh, 2006). Spraying insecticides three times on cowpea increases grain yield and net returns since the technique is attractive to farmers having different attitudes towards risk it can enhance overall cowpea production and, if promoted, its role in reducing food security and poverty among smallholder farmers in the area will be high. However, precautions should be taken during the scaling to reduce the negative externalities which may be associated with the use of the insecticide (Kotu *et al*., 2017).

MATERIALS AND METHODS

This experiment was conducted at the Teaching and Research Farm of Faculty of Agriculture (Shabu-Lafia Campus), Nasarawa State University, Keffi. Lafia is situated at Latitude 08^{o},33^{i}N and Longitude 08^{o},32^{i}E and at altitude of 160m above sea level (Jayeoba, 2013), during the 2018 and 2019 rainy seasons

Soil samples were collected randomly from the experimental site and analyzed. The soil was predominantly loamy at site 1 and loamy clay at site 2 and 3 respectively. Three cowpea varieties were used for the experiment which are Cowpea Faumpea1 and 2 obtained from the Seed Testing Centre, Federal University of Agriculture Makurdi, Benue State Nigeria; while the local variety (40 Days) was obtained from the local market in Shabu, Lafia, Nasarawa State. The contact insecticide used was, Lamda-cyhalothrin 2.5EC, purchased from reputable Agrochemical dealer in Lafia market, Nasarawa State. There were 12 treatment combinations which were replicated three times. The contact insecticide was sprayed at three different spray regimes (once, twice and three times) and the control treatment (no spray).

The experimental site was cleared by applying pre-tillage non-selective herbicide (Paraquat® {Slasher}) to clear the grasses, shrubs were cut down using cutlasses and axes. Further, the site was harrowed, pulverized and ridged

by the use of big and small African hand hoes into net plots.The gross plot size was 3m x 4m ($12m^2$) while the net plot size was at 4m x 1.5m($6m^2$) with an inter and intra row spacing of 40cm x 75cm($3000cm^{2.}$).
The three varieties of cowpea seeds were sown per hole at the depth of 2-3 cm and covered thinly at intra and inter row spacing of 40 x 70cm respectively. Thinning was carried out at 3 weeks after sowing (3 WAS) to 2 plants/stand. Five plants were randomly tagged in each of the net plots for data collection at 4, 6, 8 and 10 WAS. Data collected on plant height, number of branches, number of leaves and total dry matter; while total biological weight, grain yield per plant, haulms weight per plant, 100 seed weight and harvest index were used as yield parameters. All cultural practices were carried out as recommended.
There were two treatment combinations which were replicated three times, these combinations comprises three cowpea varieties; the local variety (V_1), cowpea Faumpea1(V_2), and cowpea Faumpea2 (V_3) and application non-systemic (Contact) insecticides(C) (Combat^R 2.5 EC (market name) known as Lamda-cyhalothrin, containing 2.5 a.i./lit EC, a contact stomach repellant insecticide) in tree spray regimes consisted zero spray (C_0), spraying once (C_1), spraying twice C_2 and spraying thrice (C_3).
The experimental design used was a Randomized Complete Block Design (RCBD) with the varieties forming the main block treatments and the various spray regime treatments allocated within the various blocks. The experiment was analyzed using GENSTAT software, version 13 and means were separated using Duncan Multiple Range Test on SPSS version 22.

RESULTS

The various treatment applied were significantly different (Table 1). In both years, Faumpea 2 variety of cowpea significantly produced the tallest plants height followed by Faumpea1 at all the sampling periods while the local variety produced significantly the shortest plants. The application of Lambda-cyhalothrin contact insecticide in the three spread regimes significantly recorded the highest plant height at both the sampling periods in both years followed by the 2nd spray regime at the respective sampling periods and wet seasons. The least in the plant height was the zero application of Lambda-cyhalothrin contact in both years (Table 1). There was significant interaction between variety and insecticide in both years, at the growth stage of 10 WAS (Table 1). The result however recorded significantly the highest number of branches on cowpea Fuampea 2 followed by Faumpea1 when Lambda-cyhalothrin insecticides was sprayed in 3 regimes while zero application of Lmabda-cyhalothrin contact insecticide produced significantly the lowest number of branches in both years at 4, 6, 8 and 10 WAS (Table 2). There was an interaction between variety and insecticide at 10 WAS in both seasons (Table 2).
The three varieties tested in 2018 and 2019 recorded significantly more number of leaves of cowpea Fuampea 2 followed by Fuampea1at all the sampling periods (Table 3). The application of Lambda-cyhalothrin insecticide in 3spray regimes recorded significantly more number of leaves of cowpea Fuampea 2 than other spray regimes in both years at all the sampling periods (Table 3). Interaction was observed between variety and insecticide at10 WAS in both 2018 and 2019 rainy season (Table 3). The treatments applied on total dry matter of cowpea recorded significant difference at all sampling periods in both 2018 and 2019 wet seasons (Table 4) where the Local cowpea variety produced significantly the least total dry matter of cowpea and Fuampea 2 (V_3) cowpea variety produced the highest total dry matter than Fuampea 1 (V_2) at all the sampling periods of 4, 6, 8 and 10 WAS in both years (Table 4).
When Lambda-cyhalothrin insecticide was applied in three spray regimes (S_3) at all sampling periods, records showed a significantly higher total dry matter of cowpea than other regimes tested in both years (Table 4). The result of this interaction revealed that, interaction between variety and insecticide was not significant at all sampling periods in both 2018 and 2019 rainy season (Table 4). Table 5 recorded significant differences among the various treatments applied where Cowpea Fuampea 2 variety (V_3) recorded significantly the highest 100 seeds weighed, more Grain Yield Per Plant (GYPP), Haulm weight per plant, Total Biological Yield (TBY) and the highest Harvest Index (HI) than the other two cowpea varieties tested in both rainy seasons, respectively. Similarly, all the various yield components tested at the course of this study was confirmed to significantly produce better than others when Lambda-cyhalothrin contact insecticide was applied in three spray regime than the plots with zero insecticide application in both years (Table 5). The application of Lambda-cyhalothrin contact insecticide in three spray regimes produced significantly more total biological yield, higher grain yield, haulms weight, 100 seed weight and the highest percentage harvest index in both 2018 and 2019 cropping seasons followed by the application of insecticide in two spray regimes (Table 5). An interaction occurred between variety and insecticide on grain yield per plants (Table 5).

Table 1: Effects of variety, and Cyhalothrin Insecticides on plant height, 2018 and 2019 wet seasons

Treatment	Plant height (cm)							
	2018				2019			
	4WAS	6WAS	8WAS	10WAS	4WAS	6WAS	8WAS	10WAS
VARIETY (V)								
Faumpea1 (V2)	13.93^b	27.43^b	34.91^b	43.13^b	11.95^b	27.99^b	42.43^b	45.08^b

Faumpea2 (V3)	16.80^{a}	28.51^{a}	36.90^{a}	53.73^{a}	12.25^{a}	28.74^{a}	44.52^{a}	52.90^{a}
Local (V1)	13.70^{b}	24.80^{c}	31.80c	27.11^{c}	10.85^{c}	26.93^{c}	37.50^{c}	50.03^{b}
SE±	o.28	0.55	0.97	0.36	0.46	0.36	0.59	0.74
F-LSD$_{0.05}$	0.79	1.54	0.69	1.01	1.05	0.83	1.35	1.71
Insecticides								
1stcyhalothrin spray(C_1)	12.11^{f}	24.88^{d}	35.90^{c}	44.13^{e}	10.63^{f}	23.92^{g}	40.79^{e}	50.20^{f}
2ndcyhalothrin spray (C_2)	13.71^{d}	27.56^{c}	40.68^{c}	46.23^{d}	12.52^{d}	26.26^{e}	44.68^{d}	53.05^{d}
3rdcyhalothrin spray (C_3)	16.76^{b}	28.50^{b}	45.05^{b}	49.58^{b}	15.74^{b}	33.02^{b}	48.86^{b}	56.04^{b}
zero cyhalothrin spray (C_0)	11.77^{g}	20.50^{e}	25.06^{e}	30.18^{h}	9.37^{h}	24.92^{b}	39.90^{f}	49.12^{g}
SE±	0.35	0.86	2.33	0.41	0.71	0.38	0.96	0.94
F-LSD$_{0.05}$	0.72	0.75	4.73	0.84	1.45	0.77	2.00	1.91
Interaction								
V x I	NS	NS	NS	*	NS	NS	NS	*

Means of the same letter(s) in each column of treatment group are not significant at 5% level of probability.
** = Significant at 5%w level of properbility. NS= Not significant*

Table 2: Effects of variety, herbicide and insecticides on Number of Branches, 2018 and 2019 wet seasons

Treatment	Number of Branches							
	2018				**2019**			
	4WAS	**6WAS**	**8WAS**	**10WAS**	**4WAS**	**6WAS**	**8WAS**	**10WAS**
VARIETY (V)								
Faumpea1 (V2)	3.58^{b}	3.36^{b}	2.37^{b}	1.90^{c}	2.00^{b}	3.75^{ab}	3.49^{b}	2.65^{a}
Faumpea2 (V3)	4.63^{a}	3.57^{a}	2.86^{a}	2.41^{a}	3.20^{a}	3.97^{a}	3.89^{a}	2.76^{a}
Local (V1)	3.06^{c}	3.22^{c}	2.00^{c}	2.31^{ab}	1.98^{c}	3..54^{c}	3.19^{c}	2.34^{b}
SE±	0.16	0.12	0.17	0.14	1.06	0.23	0.21	0.22
Insecticides								
1stcyhalothrin spray(C_1)	2.63^{b}	2.54^{e}	2.33^{c}	2.26^{c}	1.01^{c}	2.56^{ab}	3.47^{c}	2.18^{e}
2ndcyhalothrin spray (C_2)	2.40^{d}	3.10^{c}	2.83^{c}	2.35^{c}	1.91^{b}	3.23^{c}	3.15^{cd}	2.32^{bd}
3rdcyhalothrin spray (C_3)	3.32^{b}	3.40^{b}	3.49^{b}	2.76^{a}	2.97^{a}	3.75^{a}	3.52^{b}	2.74^{a}
Zero cyhalothrin (C_0)	1.22 e	2.25^{f}	2.10^{c}	2.00^{de}	1.01^{c}	2.23^{e}	2.87^{e}	2.01^{f}
SE±	0.45	0.26	0.31	0.30	0.87	0.27	0.30	0.23
Interaction								
V x I	NS	NS	NS	*	NS	NS	NS	*

Means of the same letter(s) in each column of treatment group are not significant at 5% level of probability.
** = Significant at 5% level of probability. NS= Not significant*

Table 3: Effects of variety, herbicide and insecticides on number of leaves, 2018 and 2019 wet seasons

Treatment	Number of Leaves							
	2018				**2019**			
	4WAS	**6WAS**	**8WAS**	**10WAS**	**4WAS**	**6WAS**	**8WAS**	**10WAS**
VARIETY (V)								
Faumpea1 (V2)	4.91^{b}	9.56^{b}	6.30^{a}	3.72^{ab}	7.42^{b}	10.10^{a}	12.11^{b}	6.14^{b}
Faumpea2 (V3)	7.19^{a}	9.93^{a}	6.40^{a}	4.24^{a}	7.65^{a}	10.25^{a}	13.87^{a}	7.77^{a}
Local (V1)	3.20^{c}	9.22^{c}	5.64^{b}	3.89^{ab}	7.07^{c}	9.88^{ab}	11.41^{c}	5.84^{c}
Insecticides								
1stcyhalothrin spray(C_1)	4.37^{f}	8.65^{d}	6.18^{b}	4.19^{ab}	5.51^{d}	9.18^{d}	10.38^{f}	6.85^{a}
2ndcyhalothrin spray (C_2)	5.14^{d}	9.52^{c}	6.46^{b}	4.18^{ab}	6.41^{b}	9.61^{b}	11.40^{cd}	7.13^{a}
3rdcyhalothrin spray (C_3)	5.68^{b}	10.20^{b}	6.82^{a}	4.76^{a}	7.49^{a}	10.34^{a}	12.33^{ab}	6.98^{a}
Zero cyhalothrin (C_0)	4.10^{g}	7.90^{e}	5.21^{c}	3.60^{c}	5.08^{de}	8.82^{f}	9.82^{g}	6.70^{ab}
SE±	0.25	0.31	0.33	0.35	0.41	0.56	0.41	0.44
F-LSD$_{0.05}$	0.50	0.78	0.67	0.71	0.83	1.15	0.91	0.88
Interaction								
V x I	NS	NS	NS	*	NS	NS	NS	*

Means of the same letter(s) in each column of treatment group are not significant at 5% level of probability.
** = Significant at 5% level of probability. NS= Not significant.*

Table 4: Effects of variety and Cyhalothrin Insecticides on Total Dry Matter (TDM), 2018 and 2019 wet seasons

Treatment	Total Dry Matter (kgha^{-1})							
	2018				2019			
	4WAS	6WAS	8WAS	10WAS	4WAS	6WAS	8WAS	10WAS
VARIETY (V)								
Faumpea1 (V2)	5.20^{b}	5.23^{b}	16.90^{b}	3.33^{b}	5.40^{b}	10.50^{ab}	22.50^{b}	36.60^{b}
Faumpea2 (V3)	5.80^{a}	5.80^{a}	17.90^{a}	26.40^{a}	5.47^{a}	10.74^{a}	23.30^{a}	37.20^{a}
Local (V1)	4.87^{c}	4.87^{c}	16.43^{c}	33.76^{c}	4.85^{c}	10.23^{ab}	21.30^{c}	34.95^{c}
SE±	0.16	0.16	0.24	1.13	0.27	0.22	10.11	1.25
F-LSD$_{0.05}$	0.46	0.46	0.67	3.15	0.63	0.51	23.32	2.85
Insecticides								
1stcyhalothrin spray(C$_1$)	6.02^{de}	6.02^{de}	19.02^{de}	37.91^{e}	6.09^{ef}	10.82^{d}	22.4^{d}	33.52^{d}
2ndcyhalothrin spray (C$_2$)	6.17^{d}	6.17^{d}	20.59^{c}	41.16^{cd}	7.10^{cd}	11.88^{c}	24.4^{cd}	34.75^{d}
3rdcyhalothrin spray (C$_3$)	7.68^{b}	7.68^{b}	21.85^{ab}	46.23^{b}	8.10^{ab}	12.85^{b}	26.1^{ab}	36.39^{b}
Zero cyhalothrin Spray (C$_0$)	5.30 e	5.30 e	19.73^{d}	32.38^{f}	5.46^{g}	10.29	21.6^{f}	34.13^{d}
SE±	0.40	0.40	0.72	1.89	0.41	0.53	0.85	2.18
F-LSD$_{0.05}$	0.88	0.88	1.47	3.83	8.84	1.08	20.81	4.43
Interaction								
V x I	NS	NS	*	*	NS	SN	*	*

Means of the same letter(s) in each column are not significantly different at 5% level of probability.
** = Significant at 5% level of probability; NS= Not significant*

Table 5: Effects of Variety, and Cyhalothrin Insecticides on 100 Seeds Weight, Grain Yield, Haulms Weight, Total Biological Yield and Harvest Index, 2018 and 2019 Wet Seasons

	2018					2019				
	Cowpea Yield (kg ha^{-1})									
Treatment	**100 Seeds Weight (g)**	**Grain yield Kg ha^{-1}**	**Haulms Weight (g)**	**Total Biol. Yield (kg)**	**Harvest Index (%)**	**100 Seeds Weight (g)**	**Grain yield Kg ha^{-1}**	**Haulms Weight (g)**	**Total Biol. Yield (kg)**	**Harvest Index (%)**
Variety (V)										
Fuampea1(V$_2$)	16.51^{a}	921.4^{b}	134.8^{b}	1.7^{b}	30.4^{b}	20.42^{a}	983.9^{b}	148.8^{b}	1.8^{b}	30.6^{b}
Fuampea2 (V$_3$)	17.69^{a}	1121^{a}	155.7^{a}	2.0^{a}	31.4^{a}	23.00^{a}	1192.9^{a}	165.3^{a}	2.1^{a}	31.8^{a}
Local Variety(V$_1$)	14.60^{b}	450.0^{b}	127.7^{b}	1.0^{b}	25.2^{bc}	17.00^{b}	523.2^{bc}	138.5^{c}	1.2^{b}	24.4^{c}
SE±	0.16	37.41	14.59	0.08	1.34	2.99	38.12	11.19	0..06	1.47
F-LSD$_{0.05}$	0.45	58.34	40.51	1.60	4.48	6.90	59.72	25.80	2.73	3.40
Insecticides (I)										
1st spray regime (C$_1$)	10.30c	735.7^{c}	85.2^{c}	1.5^{c}	27.5^{c}	10.2^{c}	789.3^{c}	107.3^{c}	1.6^{c}	27.6^{c}
2nd spray regime(C$_2$)	13.10^{b}	944.6^{b}	105.2^{b}	1.7^{b}	31.1^{b}	11.2^{b}	1004.3^{b}	116.2^{b}	1.8^{b}	31.4^{b}
3rd spray regime(C$_3$)	14.92^{a}	1142.9^{a}	138.2^{a}	1.9^{a}	33.7^{a}	17.2^{a}	1167.7^{a}	150.0^{a}	2.0^{a}	32.7a
Control(C$_0$)	8.60^{d}	475.0^{d}	84.3^{d}	1.2^{d}	22.2^{d}	9.6^{d}	507.1^{d}	87.8^{d}	1.2^{d}	23.7^{d}
SE±	0.37	39.41	22.2	0.03	3.64	2.23	36.92	16.92	0.05	2.65
F-LSD$_{0.05}$	0.75	68.40	46.58	5.59	7.40	8.61	54.41	34.41	73.05	5.40
Interaction										
V x I	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*Means of the same letter(s) in each column of treatment group are not significant at 5% level of probability. * = Significant at 5% level of probability. NS= Not significant*

DISCUSSION

The result of this study showed significant difference in both 2018 and 2019 rainy seasons where cowpea Fuampea 2 variety (V$_3$) consistently performed the best than the other varieties in all the various growth parameters (plants height, number of branches, number of leaves and total dry matter) tested at all the sampling periods of 4, 6, 8 and 10 WAS. The better performance of cowpea Fuampea 2 could be as a result of the genetic makeup imbibed by the variety with high tolerance, resistance and competitive traits to withstand weed suppression and insect pest infestation. This assertion agrees with Ehelers and Hall (1997) who states that substantial genetic diversity exist with growth habit characteristics and represent excellent opportunity to develop varieties with high weed suppressive ability on leguminous plants as was done in soybean, *Gycine max* (L).

Cowpea Fuampea 2 significantly yielded better than the rest of the varieties in terms of its total biological yield, grain yield per plant, haulms weight, 100-seed weight and harvest index. Cowpea Faumpea2 is an improved variety that could have come with some special genotypic traits and abilities to withstand suppression and stress which makes it to yield better than other varieties. This result is in conformity with Ehelers *et al*. (2002) and supported by Hall *et al*, 2003 who states that, cowpea varieties have been bred for a wide range of agronomic, grain quality and resistant or tolerant characteristics to abiotic and biotic stresses.

Cyahalothrin contact insecticide application in three spray regimes (C_3) consecutively showed significantly the highest performance than others in all the growth and yield parameters studied during 2018 and 2019 rainy seasons. This result is in consonance with the finding of Adati *et al.* (2008) who suggested that farmers using improved cowpea varieties would be require to apply 2-3 insecticidal spray regimes in order to increase crop yield due to the different stages of insect pest attack. This also agrees with Saro (2018) who suggested that, the use of Lambda-Cyhalothrin 2.5EC contact stomach acting repellant insecticide is good for the control of wider spectrum of insect pests in crops which in turn gives room for an uninterrupted crop growth and performances. The result of this finding indicates that the more the number of spray regimes (up to 3 spray) the better the significant growth and yield performance of cowpea.

CONCLUSION

The growth and yield parameters of cowpea Fuampea2 variety significantly better than the other cowpea varieties tested in 2018 and 2019 rainy seasons as well as application of cyhalothrin contact insecticide in 3 spray regimes also resulted as the best in the growth and yield performance of cowpea compared to the other spray regimes

RECOMMENDATIONS

The production of cowpea Fuampea2 variety is highly recommended for cultivation according to the findings of this research work due to its significant growth and yielding ability as well as its high resistivity to weeds and insect pests' damage. Application of Lambda-cyhalothrin contact insecticide in 3 spray regimes was found to significantly performed better than 1-2 spray regimes because the fewer the spray regimes the more insects attacks cowpea and low yield return will consequently be resulted.

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EFFECT OF PLANTING DATES ON YIELD AND SOME YIELD RELATED TRAITS OF COCOYAM (*COLOCASIA ESCULENTA* L IN THE RAINFOREST ZONE OF NIGERIA

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ABSTRACT
Cocoyam (Colocasia esculenta) of the family Araceae, is an importance staple food in Nigeria because of its nutritional value which makes it a health management crop, weaning food for infants and has a lot of potentials for agro industries. The study was carried out in Umudike (Lat. 5.4801˚N, Long. 7.5437˚E) in the rainforest zone in 2020 cropping season. The treatments include two cocoyam cultivars Nce 001 (Coco Indian), Nce 003 (Ede ofe) and 3 planting dates in April, May and June (10/04/2020, 10/05/2020 and 10/05/2020) laid out in randomized complete block design (RCBD) in factorial arrangement. Data were collected on number leaves, and plant height at 3 months after planting (MAP) and also on number and weight of corms and cormels during harvest. Data collected was subjected to analysis of variances using Genstat Discovery edition 1. Results obtained showed that at 3 MAP number of leaves of Nce 001 and 003 were not influence by planting dates and cultivars but planting dates had a significant influence on plant height. The planting date also had significantly impacted on number of corms, cormels and yield at harvest.
Keywords: *Cocoyam, Colocasia esculenta , Taro, Planting period, Corms, Cormels, yield.*

INTRODUCTION
Cocoyam (*Colocasia esculenta)* belongs to the aroid family Araceae. There are two important species of cocoyam *Xanthosoma sagittifolium* (Tannia) and *Colocasia esculenta* (Taro) which are grown throughout West Africa. The *Xanthosoma sagittifolium* are of two cultivars Nx 01 (white) and Nx 02 (pink) while *Colocasia esculenta* has many cultivars which include NCe 001, NCe 002, NCe 003, NCe 004, Nce 005 and NCe 006. In Nigeria it is cultivated for food security, income and economic in empowerment. It has high nutritional qualities which make it to be used as a health management crop, weaning food for infants, and in agro industries to enhanced livelihoods. It is an important carbohydrate staple food particularly in the southern and middle belt of Nigeria (Amadi *et al*, 2012) where it is consumed in various delicacies boiled, roasted or as a soup thicker depending on the cultivar. Taro corms and leaves have medicinal value which helps to reduce tuberculosis, ulcers, pulmonary congestion and fungal infection (Misra and Sriram, 2002). Among all the root and tuber crops of economic importance cocoyam is the third in position after yam and cassava. Nigeria is the largest producer of cocoyam in the world and Africa (Amadi *et a*l, 2017) with a production estimate of 2.9 million metric tonnes from 994,644 hectares in 2019 (FAOSTAT 2022 downloaded 18th June, 2023). This approximates to about 2.9 tonnes per hectare which is low compared to other competing root and tuber crops like cassava, yam, sweet-potato, and potato. Crop yield can be increased by the use of appropriate good agronomic practices and proper farm management methods which includes period planting (Ebeniro, 2019). Planting periods have been used as escape mechanisms for drought, flooding and disease management in crops production. The objective of this study is to determine the most effective planting period to optimize tuber of cocoyam in the rainforest zone of Nigeria.

MATERIALS AND METHOD
The study was carried out in National Root Crops Research Institute, Umudike experimental field in 2020 cropping season. Umudike is located on longitude 07˚ 33' E and altitude 05˚29' N and at an elevation of 122 above sea level in the rainforest zone of Nigeria. The soil is sandy loam, acidic with low buffering capacity and multiple deficiencies (Ano, 1990). The experiment contained six possible combination of treatments replicated 3 times. The treatments include two cocoyam cultivars NCe 001 (Coco Indian), NCe 003 (Ede ofe) and 3 planting periods April, May and June (10/04/2020, 10/05/2020 and 10/05/2020). The design was randomized complete block design (RCBD) in a factorial arrangement. Good agronomic management practices were carried out including site selection, land preparation, cutting and sorting of corms and cormels, weeding, fertilizer application, weeding and

harvesting. Harvesting was done 7 months after planting. Data collected on growth attributes were on number of leaves per plant, and plant height at 3 months after planting. Yield attributes assessed at harvest were numbers and weights of corms and cormels per plot, Weights were converted to yield/ hectare. Data collected were subjected to analysis of variance using Genstat Discovery Edition 1.

RESULTS

Table 1 indicated the effect of planting period on number of leaves on the two cultivars of cocoyam NCe 001 (Coco Indian), NCe 003 (Ede-ofe) at 3 months after planting. It showed neither planting period nor cultivar had a significant effect on number of cocoyam leaves. Cultivars x planting date interaction effect on number of leaves was also insignificant. The plant height of the cultivars planted in June were significantly (P<0.05) shorter at 3 MAP compared with cultivars planted in April and May. Both April and May plantings had similar plant heights. Planting period x cultivars interaction had no significant effect on plant height at 3 MAP.

Table 1: Effect of Planting period and Cultivar on Number of Leaves and Plant Height at 3 MAP

	Number of leaves				Plant height (cm)			
	Plantings Period (Months)							
Cultivars	April	May	June	Mean	April	May	June	Mean
Nce 001(Coco Indian)	5.00	5.00	5.00	5.00	5.33	47.07	37.33	45.58
Nce 003(Ede-ofe)	5.00	5.00	5.33	5.11	51.67	48;13	37.20	46.67
Mean	5.00	5.00	5.11		52.00	47.60	37.27	
LSD (0.05) for Cultivars = NS LSD (0.05) for planting periods = NS LSD (0.05) for Cultivars x planting periods = NS					LSD (0.05) for Cultivars = NS LSD (0.05) for planting periods = 0.001 LSD (0.05) for Cultivars x planting periods = NS			

On the number of corms and cormels at harvest both cultivars and planting period had a significant effect. The effect of cultivar and planting period on number of corms, cormels and tuber yield of cocoyam is presented in Table 2. Nce 003 had more corms than Nce 001 at all planting periods while early planting (ie planting in April) gave the highest number of corms. Number of cormels followed the same pattern as number of corms. In terms of tuber yield (t/ha), the two cocoyam cultivars evaluated did not differ significantly. However, planting in April gave the highest yield compared to other planting periods. Planting date x cultivar interaction did not significantly affect number of corms and cormels, and tuber yield of cocoyam (Table 2).

Table 2: Effect of Planting periods and Cultivars on number of Corms and Cormels, and yield (t/ha) at harvest.

	Corms				Cormels				Yield (t/ha)			
					Planting periods							
Cultivars	April	May	June	Mean	April	May	June	Mean	April	May	June	Mean
Nce 001	12.67	9.92	6.33	9.64	11.08	8.92	5.33	8.44	11.70	9.44	5.03	8.72
Nce 003	17.50	48.83	10.75	14.36	16.67	13.83	0.92	13.47	10.61	9.05	5.51	8.39
Mean	15.08	12.67	8.54		13.88	11.38	7.62		11.15	9.25	5.27	
LSD (0.05) for Cultivars = 0.032 LSD (0.05) for planting periods = 0.20 LSD (0.05) for Cultivars x planting periods = NS					LSD (0.05) for Cultivars = 0.016 LSD (0.05) for planting periods = 0.02 LSD (0.05) for Cultivars x planting periods = NS				LSD (0.05) for Cultivars = NS LSD (0.05) for planting periods = 0.01 LSD (0.05) for Cultivars x planting periods = NS			

DISCUSSION

Crop yield can be increased by the use of appropriate good agronomic practices/techniques and proper farm management methods include time of planting (Ebeniro, 2019). Early planting is a means reducing the effects of evading drought, flooding, pests and diseases in crops during the cropping season. Results obtained from this study indicate that early planting (ie planting in April) resulted in taller more robust plants which gave highest tuber yield compared to other planting periods especially the late planting in June. Nce 003 produced more number of corms and cormels but did not significantly out-yield Nce 001. The increased yield obtained from April planting could be due to evasion of the peak period of Taro Leaf blight (TLB) which is the most destructive disease of cocoyam. This disease is caused by an oomycetes known as *Phytophthora colocasiae* which thrives under high moisture conditions prevalent at the peak of rainy season (Misra *et al*, 2008; Omane *et al*., 2012). Early planting enables the plants to go far in growth and tuberization before the advent of TLB.

CONCLUSION

Result obtained from this study showed clearly that planting early in the rainy season (April Planting period) resulted in higher yield. Farmers are therefore adviced to plant NCe 001 and NCe 003 early in the season optimum tuber yield.

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EFFECT OF PLANTING DATE ON SOME AGRONOMIC CHARACTERISTICS AND YIELD OF COCOYAM (*COLOCASIA ESCULENTA*) IN UMUDIKE, RAINFOREST AGRO-ECOLOGICAL ZONE OF NIGERIA

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ABSTRACT

The study was carried out in National Root Crops Research Institute, Umudike experimental field in 2020 cropping season to determine the effect of planting date on some agronomic characteristics and yield of Cocoyam (Colocasia esculenta). The experiment was set up in in randomized complete block design (RCBD) in factorial arrangement. The experiment contained six possible combination replicated 3 times. The treatments were two cocoyam cultivars Nce 001 (coco Indian), Nce 003 (ede ofe) and 3 planting dates April (10/04/2020, May (10/05/2020 and June (10/06/2020). Data were collected on number of leaves, plant height at 3 months after planting, number corms, cormels and yield (t/ha) at harvest. Data collected were subjected to analysis of variances using GENSTAT DISCOVERY edition 1 (Laws Agriculture Trust, 2003). The number of leaves per plant and plant height did not significantly differ amongst the cultivars tested. For planting date, the plants were significantly taller when planted in April compared with the other dates assessed. The corm and cormel were significantly higher (p<0.05) in the cultivar Nce 003 compared with Nce 001. Yield (t/ha) was not significantly different amongst the cultivars. Corm, cornmel and yield (t/ha) were all significantly (p<0.05) higher in cocoyam planted in April compared with the other months

Keywords: *Cocoyam, Taro, planting dated, , growth, yield.*

INTRODUCTION

Cocoyam belonging to family Areaceae is one of the important food crops in some rural communities in Nigeria. Two important varieties of the crop: *Xanthosoma sagittifolium* and *Colocasia esculenta* are grown throughout West Africa. The *Xanthosoma sagittifolium* are of two cultivars white and pink while *Colocasia esculenta* have many cultivars which include NCe 001, NCe 002, NCe 003, NCe 004, Nce 005 and NCe 003. In Nigeria it is cultivated for foodwhile the excess are sold for income to the farm family. It has high nutritional qualities and hence is used in management of some health conditions and weaning food for infants. It is an important carbohydrate staple food particularly in the southern and middle belt of Nigeria (Amadi *et al*, 2012). Taro corms and leaves have medicinal value which helps to reduce tuberculosis, ulcers, pulmonary congestion and fungal infection (Misra and Sriram, 2002). Among all the root and tuber crops of economic importance cocoyam is the third in position after yam and cassava. Nigeria is the largest producer of cocoyam in the world (Amadi *et al*, 2017) with a production estimate of 2.9 million metric tonnes from 994,644 hectares in 2019. s(Ebeniro, 2019). The objective of this study was to determine the effect of planting date on some agronomic characteristics and yield of Cocoyam in Umudike, Nigeria

MATERIAL AND METHODS˚

The study was carried out at the National Root Crops Research Institute, Umudike Experimental Field in 2020 cropping season. Umudike is located on longitude 07˚ 33' E and altitude 05˚29' N and at an elevation of 122 above sea level in the rainforest agro- ecological zone of Nigeria. The soil is sandy loam which is acidic with low buffering capacity and multiple deficiencies (Ano, 1990). The design was randomized complete block design (RCBD) in a factorial arrangement, replicated 3 times. The treatments include two cocoyam cultivars NCe 001 (coco Indian), NCe 003 (ede ofe) and 3 planting periods April (10/04/2020, May (10/05/2020 and June (10/06/2020). Good agronomic management practices were done such as site selection, land preparation, marking of field, cutting and sorting of corms and cormels, weeding, fertilizer application, good field maintenance and harvesting. Harvesting was done 10 months after planting. Data collected on growth attributes were on number of leaves per plant, plant height at 3 months after planting and yield attributes on number of corms, cormels and yield(t/ha) at harvest. Data collected were subjected to analysis of variance using GENSTAT DISCOVERY edition 1 (Laws Agriculture Trust, 2003)

RESULTS

Table 1 show the effect of planting date on number of leaves and plant height of cocoyam at Umudike during the 2020 cropping season. The number of leaves per plant and plant height did not significantly differ amongst the cultivars tested. With respect to planting date, the plants were significantly taller when planted in April compared with the other dates assessed. There were no significant interactions in the treatments tested.

The effect of cultivar and planting dates on the corm, cormel and yield of cocoyam is presented in Table 2.The corm and cormel were significantly higher ($p<0.05$) in the cultivar Nce 003 compared with Nce 001. Yield (t/ha) was not significantly different amongst the cultivars. For planting date, corm, cornmel and yield were all significantly ($p<0.05$) higher in cocoyam planted in April compared with the other months.

DISCUSSION.

Crop yield can be increased by the use of appropriate good agronomic practices/techniques and proper farm management methods include time of planting (Ebeniro, 2019). Early planting is a means of reducing the effects of pests and diseases in crops during the cropping season. . Planting periods have been used to check diseases on potato and sweetpotato (Mishra *et al.* 2008) which can be used as a means of control in other crops of root and tuber. The most effective planting period to grow cocoyam for good yeld in the rain forest zone of Nigeria is 4th month of the year (April), Th NCe 001 and NCe 003 planted in the 4th month of the year (April) had had significantly higher yield than other periods of the year.

CONCLUSION

From the study farmers are advised to plant NCe 001 and NCe 003 in April tfor good yield of the cocoyam.

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Table 1: Effect of planting date on 2 cultivars of cocoyam (Nce 001 and Nce 003) on number of leaves and plant height at 3 months after planting

	Number of leaves				Plant height (cm)			
	Plantings Period (Months)							
Cultivars	April	May	June	Mean	April	May	June	Mean
Nce 001(Coco Indian)	5.00	5.00	5.00	5.00	5.33	47.07	37.33	45.58
Nce 003(Edeofe)	5.00	5.00	5.33	5.11	51.67	48;13	37.20	46.67
Mean	5.00	5.00	5.11		52.00	47.60	37.27	
LSD (0.05) for Cultivars = NS					LSD (0.05) for Cultivars = NS			
LSD (0.05) for planting date = NS					LSD (0.05) for planting date = 0.001			
LSD (0.05) for Cultivars x planting date = NS					LSD (0.05) for Cultivars x planting date = NS			

Table 2: Effect of planting periods on 2 cultivars of cocoyam (Nce 001 and Nce 003) of number of corms, cormels and yield at harvest (t/ha)

	Corms				Cormels				Yield (t/ha)			
	Planting periods											
Cultivars	April	May	June	Mean	April	May	June	Mean	April	May	June	Mean
Nce 001	12.67	9.92	6.33	9.64	11.08	8.92	5.33	8.44	11.70	9.44	5.03	8.72
Nce 003	17.50	48.83	10.75	14.36	16.67	13.83	0.92	13.47	10.61	9.05	5.51	8.39

Mean	15. 08	12.67	8.54	13.88	11.38	7.62	11.15	9.25	5.27

LSD (0.05) for Cultivars = 0.032 LSD (0.05) for planting periods = 0.20 LSD (0.05) for Cultivars x planting periods = NS	LSD (0.05) for Cultivars = 0.016 LSD (0.05) for planting periods = 0.02 LSD (0.05) for Cultivars x planting periods = NS	LSD (0.05) for Cultivars = NS LSD (0.05) for planting periods = 0.01 LSD (0.05) for Cultivars x planting periods = NS

ASSESSMENT OF THE LEVEL OF ADOPTION OF LATE BLIGHT DISEASE CONTROL INNOVATIONS AND THEIR IMPACT ON THE LIVELIHOOD OF POTATO FARMERS IN JOS PLATEAU NIGERIA

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ABSTRACT
Late blight disease (LBD) caused by Phytophthora infestans is among the major cause of low yield obtained by potato farmers in Nigeria. This study was undertaken in 2022 in Jos South, Ryiom, Barkin-Ladi, Bokkos, and Mangu LGAs in Jos Plateau of Plateau State to ascertain the level of adoption of the control innovations for LBD disseminated by the National Root Crops Research Institute (NRCRI) Umudike over a decade ago and their impact on the livelihood of adopting farmers. Data were collected from one hundred and twenty (120) potato farmers using a structured and pretested questionnaire. These respondents were among those previously trained in the use of reference technologies. Results obtained indicate a high awareness (65.8 to 77.5%) of late blight management innovations disseminated by NRCRI. There was a high adoption of early planting (73.3%) and the use of fungicides (70.8%) for late blight disease control. There was however low adoption of the use of resistance varieties for controlling the disease (42.5%). The educational status, marital status, and farm size of the respondents had significant positive effects on the level of adoption, while farming experience and membership in cooperative society had significant negative effects on the adoption of the reference technologies. Amongst the constraints to adoption assessed, low knowledge of innovation ranked the highest while cattle menace was the least. The impact of the adoption of reference technologies was low. Despite the high adoption, there was a generally low impact of reference technologies on the livelihood of respondents. We, therefore, recommend the development and deployment of potato varieties resistant to late blight; reassessment of available fungicides for the control of late blight for recommendation to farmers; and re-training of farmers and extension officers on the appropriate application of the technologies

Keywords: *Late blight, Phytophthora infestans Disease control, Innovations, Awareness, Adoption, Impact*

INTRODUCTION
Potato (*Solanum tuberosum* L.) is an important food for many in Nigeria because of its nutritional and organoleptic qualities. Potato tubers contain a higher amount of carbohydrates, and protein per hectare compared to cereals and are a good source of vitamin C, B12, potassium, and fibre (Ghislain *et al*., 2021). In addition, potato is a short-duration crop (90-120 days) and can therefore be grown multiple times within a year. It does well both under rain-fed and irrigated production. The production estimate for potatoes in Nigeria in 2021 is 1.2 million metric tonnes from 319,180 hectares (FAOSTAT, 2021). The average yield is about 3.8 t/ha is very low. Among the major causes of low yield obtained by potato farmers in Nigeria is Late blight disease (LBD)..

Late blight disease of potatoes is caused by *Phytophthora infestans* (Mont.) de Bary. The pathogen belongs to a fungus-like group of ubiquitous organisms known as oomycetes (water moulds). The disease develops and spreads rapidly under high relative humidity, moderate temperature, and substantial rainfall. It infects potato leaves, stems, and tubers at any stage of development and has the potential to destroy the whole potato field within a few days (Tafesse *et al*., 2018). Amadi *et al.* (2021), reported yield reductions between 20-50% due to the disease while Chingle and Kwun-Ndung. (2019), reported that in some severe cases it may lead to total yield loss. It can also lead to serious post-harvest decay of tubers in storage (Johnson, 2008). LBD is of great economic significance. Based on a price of $150 per ton for Potato, the cost of late blight disease is estimated at between $42,000,000 – $105,000,000, per annum. The yield decline and attendant financial loss caused by LBD, reduce food availability, increase food prices, and pose a danger to the income and livelihoods of rural households (Amadi *et al.* 2021, Chuwang, 2014).

Considering the magnitude of yield reduction caused by LBD, the National Root Crops Research Institute (NRCRI) Umudike through her Potato Research Programme, had developed and disseminated to potato farmers on the Jos Plateau over a decade ago, some innovations to control the disease. These innovations include early planting (April-early May) at the onset of rain to escape the peak period for late blight; recommendations on fungicide use and the use of resistant varieties (RC767-2) for the control of late blight. Adoption of these technologies has the potential to reduce disease, increased seed quality, and increase the yield, income, and livelihood of adopting farmers. However, the adoption of improved agricultural innovations has been a long-term concern of agricultural experts, policy makers, agricultural researchers, and many others linked to the sector (Amadi *et al*. 2022). Having disseminated these innovations to potato farmers on the Jos plateau over a decade ago through direct training or indirectly through the training of extension officials who then trained farmers, it is appropriate to assess their level of adoption by farmers and the impact their adoption has had on the income and livelihood of farmers.

The objectives of this study, therefore, were to ascertain the level of awareness and adoption of NRCRI control measures for LBD by potato farmers in Jos Plateau and the impact of their adoption; in order to guide future institutional and policy interventions.

METHODOLOGY

This study was carried out in Jos south, Ryiom, Barkin-ladi, Bokkos and Mangu LGAs of Jos plateau in Plateau State Nigeria in 2022. A purposive and multi-stage sampling technique was used in selecting 120 potato farmers 24 from each LGA as respondents. The instrument for data collection was a set of structured and pre-tested questionnaires. The primary data gathered included the socioeconomic characteristics of respondents, identification of late blight disease symptoms, level of awareness, adoption, impact, and constraints on the adoption of LBD control innovations developed and disseminated by NRCRI Umudike. Descriptive statistics was used to analyse the data generated from the study.

RESULTS AND DISCUSSION

Prevalence and identification of Late blight disease.

The Prevalence of LBD and farmers' ability to identify them are presented in Table 1. A vast majority of the farmers 62% were able to identify symptoms of LBD on their farms while 80% of the farms were attacked by LBD. This indicates a high prevalence of the disease on potato farms in the Jos plateau. The high level of identification and hence awareness reported in this study is in tandem with the report by Farm Radio International (April 9, 2020) "Almost every farmer who has ever grown potatoes has stories of this disease wiping out some or all of their harvest". It is however contrary to Nnadi *et al*., (2019) who reported that farmers' awareness of the disease was very poor and most of the farmers had not heard of *P. infestans*, attributing the disease to supernatural causes, rain, or dew. It is possible that Nnadi *et al*, (2019) tagged their awareness of the disease to the identification of the pathogen. It is possible for farmers to be aware of a disease without knowing what causes it.

Table 1: The distribution of the respondents according to the identification of late blight disease.

Variables	Yes	No
Can you identify LBD?	74(61.7)	46(38.3)
Is your farm attacked by LBD	96 (80.0)	24 (20.0)

Source: field survey, 2022; Note: figures in parenthesis are the percentages (%)

Level of Awareness of Late Blight Control Innovations

The distribution of the respondents according to their level of awareness of LBD control innovations is presented in Table 2. There was a high degree of awareness of LBD control innovations disseminated by NRCRI as a majority of the respondents 77.5%, 73.3%, and 65.8% were aware of early planting, use of fungicides, and use of resistant varieties respectively. This result is in agreement with the interview by Farm Radio International (2020) which showed that most of the farmers interviewed knew about these innovations.

Table 2: The distribution of the respondents according to their level of awareness of LBD control innovations

Variables	Not aware	Aware
Early planting	27(22.5)	93(77.5)
Fungicide	32(26.7)	88 (73.3)
Use of resistant varieties	41(34.2)	79 (65.8)

Source: field survey, 2022; Note: figures in parenthesis are the percentages (%)

Level of Adoption of Late Blight Disease Control Innovations

Rogers (1995) defined adoption as the decision to make full use of an innovation or technology as the best course of action available. The distribution of respondents based on their level of adoption of LBD control innovations in the study area is presented in Table 3. The result revealed a grand mean of 2.29, implying a generally strong adoption of most innovations based on a cut-off point of 2.0. The result specifically revealed high adoption of early planting technology (73.3%) and use of fungicide (70.8%). There was however low adoption of the use of resistant varieties with adoption rates of (42.5%). Tesfaye *et al*., (2018) reported high adoption of the use of fungicides to control late blight in the Jeldu woreda area of Ethiopia. The low-level adoption of the use of resistant or tolerant varieties by potato farmers could be attributed to their unavailability or breakdown.

Table 3: The distribution of the respondents according to their level of adoption of late blight disease control technologies

Variables	Never Adopted	Adopted and Stopped	Adopted and still using	Mean	Decision
Late Blight					
Early planting	26(21.7)	6(5.0)	88(73.3)	2.52	Adopted
Fungicide	25(20.8)	10(8.3)	85(70.8)	2.50	Adopted
Use resistant varieties	61(50.8)	8(6.7)	51 (42.5)	1.92	Not
Grand mean				2.31	

Source: field survey, 2022; Note: figures in parenthesis are the percentages (%), Key: Adopted and still using (3), Adopted and stopped (2) Never adopted (1). Decision: mean > 2.0 high and mean < 2.0 low

Constraints to Adoption of LBD Control Innovations

Table 4 shows the mean of the various constraints faced in the adoption of LBD control innovations by potato farmers in Plateau State. The result indicated a grand mean of 1.45 implying low constraints to the adoption of LBD control innovations. The result specifically revealed low knowledge of innovation (1.78) as the most important constraint. It appears that low constraints resulted in the high adoption recorded in this study.

Table 4: Constraints faced in the adoption of late blight control innovations by potato farmers

Constraints	Mean	Rank	Decision
Low Knowledge of innovation	1.78	1	Low
No access to extension bulletins	1.54	2	Low
Lack of input	1.50	3	Low
Insecurity	1.47	4	Low
Scarcity/high cost of labour	1.30	5	Low
Lack of fund	1.29	6	Low
Cattle menace	1.25	7	Low
Grand mean	1.45		

Source: field survey, 2022, Key: Very serious (3), Serious (2), Not serious (1); Decision: mean > 2.0 high and mean < 2.0 low

Impact of NRCRI Late blight disease innovations on the livelihood of potato farmers

The result in Table 5 showed the mean level of impact of LBD control innovations on the livelihood of potato farmers in the study area. Based on a cut-off point of 3, the grand mean of 2.27 obtained implied a generally low impact on the livelihood of respondents. This result is consistent with the prevailing hardship as a result of losses by farmers due to the recurrent epidemic of late blight in the study area. However, the result was not consistent with the report of Tesfaye *et al.*, (2013), who reported that the adoption of potato production technologies resulted in some impact on the livelihood of adopters in Oromiya and Amhara regions in Ethiopia. These general low-level impacts could be attributed to the poor application of the innovations, the ineffectiveness of available fungicides for late blight, and the unavailability, or the breaking down of resistance in hitherto resistant varieties resulting in farmers not getting the desired result from applied technologies.

Table 5: Impact of adoption of bacteria wilt control innovations on the livelihood of potato farmers

Variables	Mean	Rank	Decision
Purchase of TV/radio	2.70	1	Low impact
Built house	2.42	2	Low impact
Purchase of cycles/car	2.40	3	Low impact
Purchase of cloths	2.36	4	Low impact
Purchase of land	2.35	5	Low impact
Acquired new properties	2.32	6	Low impact
Provision of medical care	2.12	7	Low impact
Children's education	2.01	8	Low impact
Increased production	1.71	9	Low impact
Grand mean	2.27		

Source: field survey, 2022; LI – Low impact. Key: (5) Strongly agree (4) Agree (3) Disagree (2) strongly disagree (1) undecided Decision: mean > 3.0 high and mean < 3.0 low

CONCLUSION

From this study, it is evident that there is a high level of awareness (65.8 to 77.5%) of NRCRI late blight disease control innovations by the respondents. There was also high level of adoption by farmers of early planting (73.3%) and use of fungicides (70.8%) for the control of LBD. There was however low impact of adoption on the livelihood of adopting farmers. This could be a result of poor application of the technologies, ineffectiveness of some recommended fungicides due to acquired resistance by the pathogen, and the unavailability, or the breaking down of resistance in hitherto resistant varieties. It is evident from this study that there is a dire need to develop and deploy to farmers potato varieties resistant to late blight; reassess available fungicides for the control of late blight for recommendation to farmers; and re-train farmers and extension officers on the appropriate application of the technologies.

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ASSESSMENT OF THE LEVEL OF ADOPTION AND IMPACT OF BACTERIAL WILT DISEASE MANAGEMENT STRATEGIES BY POTATO FARMERS IN JOS PLATEAU, NIGERIA

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ABSTRACT
Bacterial wilt caused by Ralstonia solanocearum is the second most important disease causing low yield obtained by potato farmers in Nigeria. National Root Crops Research Institute (NRCRI) Umudike disseminated over a decade ago four management strategies namely clean seed, rouging, farm sanitation, and use of tolerant varieties for mitigating this disease. This study was conducted in 2022 in five LGAs - Jos South, Ryiom, Barkin-Ladi, Bokkos, and Mangu in Jos Plateau of Plateau State Nigeria. The objectives of the study were to ascertain the level of adoption by farmers of these management technologies and their impact on the livelihood of adopting farmers. Data were collected from one hundred and twenty (120) potato farmers selected from those who were previously trained in the use of the reference technologies. A structured and pretested questionnaire was used to elicit data. Descriptive statistics were used to analyse the data. Results obtained indicate that there was a high awareness (66.7 to 74.2%) of bacterial wilt management technologies disseminated by NRCRI. There was a high adoption of the use of clean seed (74.2%), rouging (71.7%), and farm sanitation (56.7%)for the management of bacterial wilt disease. There was however low adoption of the use of tolerant varieties (45.0%). The impact of the adoption of the use of clean seed, rouging, and farm sanitation on the livelihood of the respondents was low
Keywords: *Awareness, Adoption, Bacterial wilt, Ralstonia solanocearum, Disease control, Technologies*

INTRODUCTION
Potato (*Solanum tuberosum* L.) is an essential food for many in Nigeria because of its nutritional and organoleptic qualities. Potato is a short-duration crop (90-120 days) and can therefore be grown multiple times within a year. It does well both under rain-fed and irrigated production. 1.2 million metric tonnes of potatoes were produced from 319,180 hectares (FAOSTAT, 2021). At about 4.3 t/ha, potato yield in Nigeria is far below the global average of about 21.4 t/ha. Among the major causes of low yield obtained by potato farmers in Nigeria is the prevalence of bacterial wilt disease.
Bacterial wilt is caused by an invasive soil bacterium known as *Ralstonia solanocearum* which has a wide geographical distribution (Yabuuchi *et al*, 1995, Genin, 2010). It is the second most important potato disease in tropical and sub-tropical regions of the world after late blight (Champoiseau *et al*., 2010). Bacterial wilt infects plants through wounds and natural fissures, colonizes the vascular system, and produces large amounts of extracellular polysaccharides, which causes a blockage of the water and nutrient flow within the plant leading to wilting and death of the host plant (Schell, 2000, Sharma *et al*., 2017). After the death of the host, the bacterium returns to the soil and become saprophytic until it finds another host (Genin, 2010). It also infects tubers causing them to rot. A cross-section through such tubers shows brownish discolouration of the vascular system hence the disease is sometimes referred to as brown rot (Fig 1).

Figure 1: Wilted plants; Cross section through the tuber showing a brown discolouration of the vascular system

National Root Crops Research Institute (NRCRI) Umudike through her Potato Research Programme, had over a decade ago, disseminated to potato farmers on the Jos Plateau, some technologies for the management of this disease. These technologies include the use of the clean disease-free seed, farm sanitation, rouging, and use of tolerant varieties for the control of bacterial wilt. These technologies were disseminated through the training of extension agents and farmers. Having disseminated these technologies to potato farmers on the Jos plateau over a decade ago, it is appropriate to assess the level of adoption of these technologies by farmers and the impact their adoption has had on the income and livelihood of adopting farmers.

This study, therefore, was meant to ascertain the level of awareness and adoption of these control measures for bacterial wilt disease by potato farmers in Jos Plateau and the impact their adoption had on the livelihood of farmers.

METHODOLOGY

This study was carried out in 2022. A purposive and multi-stage sampling technique was used in selecting one hundred and twenty (120) potato farmers as respondents. Twenty-four respondents were selected from each of the five major potato-growing local government areas in Plateau State namely Jos South, Ryiom, Barkin-Ladi, Bokkos, and Mangu. The respondents were selected from farmers who were previously trained in the use of the reference technologies. The instrument for data collection was a set of structured and pre-tested questionnaires. The primary data gathered included the socio-economic characteristics of respondents, ability to identify bacterial wilt symptoms (Figure 1) on their farms, level of awareness, adoption, impact, and constraints on the adoption of bacterial wilt disease control innovations disseminated by NRCRI Umudike. Descriptive statistics was used to analyze the data generated from the study.

RESULTS AND DISCUSSION

Socioeconomic characteristic of potato farmers in Plateau State

Table 1 shows the socioeconomic characteristics of respondents. Sixty percent of the respondents were within the young highly productive age range of 31-50 years and 94.2% had some form of formal education and thus are expected to be vibrant enough to be receptive to innovations and possess good knowledge of the phenomenon under study. The result corroborates with the findings of Akinbile *et al* (2013), Efiong *et al* (2014), and Onu *et al.*, (2020). Agwu *et al*., (2008) considered young age an advantage for increased investment and improved technology utilization and hence innovativeness. The Majority of the respondents (51%) had fairly large households (6-10 persons) indicating the abundance of family labour while 63% of them had more than 10 years of experience in potato farming. Seventy-four percent had a farm size of less than 2ha while 50% earned ₦300,000 or less per annum from their potato farm indicating that they were small-scale farmers with low income. A greater majority (59.2%) of the respondents were not members of any cooperative society, which could influence their farming activities negatively.

Table 1: The distribution of the respondents according to their socio-economic characteristics

Variables	Categories	Frequency (n =120)	Percentage	Mean
Age				40.57
	≤30	26	20.6	
	31 – 40	29	22.1	
	41 – 50	48	44.2	
	51 – 60	16	12.3	
	≥61	1	0.8	
Educational level				3.16
	No formal education	7	5.8	
	Primary education	15	12.5	
	Secondary education	50	41.7	
	Tertiary education	48	40.0	
Marital Status				
	Single	18	15.0	
	Married	96	80.0	
	Widow	6	5.0	
Household size				6.42
	≤5	48	40.1	
	6 – 10	62	51.6	
	≥11	10	8.3	
farming experience				17.03
	≤10	44	36.7	
	11 – 20	41	34.2	
	21 – 30	26	21.6	
	≥31	9	7.5	
Farm size				2.19
	≤2ha	89	74.1	
	3ha – 4ha	24	20.2	
	≥5ha	7	5.7	
Annual income				
	≤300,000	60	50.0	
	301,000-500,000	26	24.2	
	≥501,000	28	25.8	
Membership of cooperative				
	Yes	49	40.8	
	No	71	59.2	

Source: field survey, 2022

Prevalence and identification of bacterial wilt disease.

Sixty-one percent of the farmers were able to identify symptoms of bacterial wilt disease (wilting of plants and brown ring inside the tuber) on their farms while 80% of the farms were attacked by the disease. This indicates a high prevalence of the disease on potato farms in the Jos plateau.

Table 2: The distribution of the respondents according to the identification of disease.

Variables	Yes	No
Can you identify the bacterial wilt disease?	73 (60.8)	47 (39.2)
Is your farm attacked by bacterial wilt disease	96 (80.0)	24 (20.0)

Source: field survey, 2022; Note: figures in parenthesis are the percentages (%)

Level of awareness of bacterial wilt control technologies

Table 3 revealed the distribution of the respondents according to their level of awareness of bacterial wilt disease control technologies. There was a high degree of awareness of bacterial wilt management technologies in the study area as 74.2%, 66.7%, 69.2% and 67.5% of the respondents were aware of the use of clean seeds, use of tolerant varieties, farm sanitation, and rouging respectively. Bagamba *et al*., (2006) reported high awareness by Ugandan banana farmers of the control measures for banana bacterial wilt disease. High awareness of technology is an indication of efficient dissemination.

Table 3: The distribution of the respondents according to their level of awareness of bacterial wilt disease management technologies

Variables	Not aware	Aware
Use of clean seed	31(25.8)	89(74.2)
Use of tolerant varieties	40(33.3)	80 (66.7)
Farm sanitation	37(30.8)	83(69.2)
Rouging	39(32.5)	81 (67.5)

Source: field survey, 2022; Note: figures in parenthesis are the percentages (%)

Level of adoption of bacterial wilt control technologies

The distribution of respondents based on their level of adoption of NRCRI bacterial wilt control technologies in the study area is presented in Table 4. The result revealed a grand mean of 2.27, implying a generally strong adoption of most disease control technologies based on a cut-off point of 2.0. The result specifically revealed high adoption of the use of clean seed (2.50), farm sanitation (2.18), and rouging (2.45). There was however low adoption of the use of resistant or tolerant varieties for controlling the disease. Smallholder potato farmers in Kenya, practiced mainly removing and throwing away diseased or infected plants (a form of field sanitation/hygiene) to control of bacterial wilt (Okello *et al*., 2020). Bagamba *et al*., (2006), reported low adoption of control measures for the control of banana wilt disease by farmers in Uganda.

Table 4: The distribution of the respondents according to their level of adoption

Variables	Never Adopted	Adopted and Stopped	Adopted and still using	Mean	Decision
Use of clean seed	29(24.2)	2(1.7)	89(74.2)	2.50	Adopted
Use of tolerant varieties	61(50.8)	5(4.2)	54(45.0)	1.94	Not
Farm sanitation	46(38.3)	6(5.0)	68(56.7)	2.18	Adopted
Rouging	32 (26.7)	2(1.7)	86(71.7)	2.45	Adopted
Grand mean				2.27	

Source: field survey, 2022; Note: figures in parenthesis are the percentages (%), Key: Adopted and still using (3), Adopted and stopped (2) Never adopted (1). Decision: mean > 2.0 high and mean < 2.0 low

Constraints to the adoption of bacterial wilt control technologies

Table 5 presents the mean of the various constraints faced in the adoption of bacterial wilt control technologies by potato farmers in the Jos Plateau. The result revealed a grand mean of 1.45 implying low constraints of adoption of the reference technologies. However, in terms of ranking, low knowledge of innovation was the most important constraint while cattle menace was of least importance. Low constraints may have resulted in the high adoption recorded in this study.

Table 5: Constraints faced in the adoption of bacterial wilt control technologies by potato farmers

Constraints	Mean	Rank	Decision
Lack of fund	1.29	6	Low
Low Knowledge of innovation	1.78	1	Low
Lack of input	1.50	3	Low
No access to extension bulletins	1.54	2	Low
Scarcity/high cost of labour	1.30	5	Low
Insecurity	1.47	4	Low

Cattle menace	1.25	7	Low
Grand mean	1.45		

Source: field survey, 2022, Key: Very serious (3), Serious (2), Not serious (1); Decision: mean > 2.0 high and mean < 2.0 low

Impact of adoption of bacterial wilt technologies on the livelihood of potato farmers

The result in Table 6 showed the mean level of impact of bacterial wilt control technologies on the livelihood of potato farmers in the study area. Based on a cut-off point of 3, the grand mean of 2.27 obtained implied a generally low impact of reference technologies on the livelihood of respondents. The result was not consistent with the report of Tesfaye *et al.*, (2013), who reported that the adoption of potato production technologies resulted in some impact on the livelihood of adopters in Oromiya and Amhara regions in Ethiopia. These general low-level impacts could be attributed to the poor application of the technologies resulting in farmers not getting the desired result from them.

Table 6: Impact of adoption of bacteria wilt control technologies on the livelihood of potato farmers

Variables	Mean	Rank	Decision
Increased production	1.71	9	Low impact
Children's education	2.01	8	Low impact
Purchase of cloths	2.36	4	Low impact
Acquired new properties	2.32	6	Low impact
Provision of medical care	2.12	7	Low impact
Purchase of land	2.35	5	Low impact
Purchase of TV/radio	2.70	1	Low impact
Purchase of cycles/car	2.40	3	Low impact
Built house	2.42	2	Low impact
Grand mean	2.27		

Source: field survey, 2022; LI – Low impact. Key: (5) Strongly agree (4) Agree (3) Disagree (2) strongly disagree (1) undecided Decision: mean > 3.0 high and mean < 3.0 low

CONCLUSION

From this study, it is evident that there is a high level of adoption of the use of clean seed, rouging, and farm sanitation for bacterial wilt disease management by potato farmers in the study area. This however did not translate into a high impact on their livelihood. The re-training of farmers and extension officers on the appropriate application of the technologies for better impact is hereby recommended.

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ASSESSMENT OF LEAD (PB) AND CADMIUM (CD) BIOACCUMULATION LEVELS ON PHYSIOLOGY AND AGRONOMIC PERFORMANCE OF TWO OKRA *(ABELMOSCHUS ESCULENTUS L.* (MOENCH) VARIETIES GROWN ON SOIL CONTAMINATED WITH SPENT LUBRICATING OIL

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ABSTRACT
Soil contamination with spent lubricating oil can negatively impact the productivity and safety of crops. The study assessed the bioaccumulation of Lead (Pb) and Cadmium (Cd) levels on Physiology and Agronomic performance of two okra varieties grown on soil contaminated with spent lubricating oil (SLO). The experiment was a 2 x 5 factorial scheme of 2 okra varieties and 5 different rates of SLO arranged in a Completely Randomized Design (CRD) with three replications. 40 plastic containers of 7 litre capacity were perforated at the bottom and filled with top soil. The two okra varieties used for this experiment were (i) Dogo (an indigenous variety) and LD-88 (an improved variety) while the treatments consisted of T0: 0 ml, T1: 5 ml, T2: 10 ml, T3: 15 ml, T4: 20 ml (w/v). The plants were harvested eight weeks after planting while the leaf and pods were analyzed for lead and cadmium bioaccumulation for each of the tested varieties. The result of the study revealed that all the seeds germinated on soil contaminated with spent lubricating oil for both okra varieties at the 5ml treatment. Conversely, there was a progressive decline in the percentage germination and the mean germination time for okra seeds at higher concentration of SLO for both varieties. The result also indicated that growth characters of plant height, number of leaves and branches and leaf area development were significantly higher at 0ml control. Lower values were however recorded for both okra varieties at higher concentrations of SLO. The result on yield and yield characters revealed that days to first flowering were significantly shorter under the 0ml control over other treatments. Conversely, the more the concentration of SLO in the soil, the longer it took both okra varieties to flower. At 10ml concentration, there was only a trace of Cadmium detected while 0.04mg/kg of lead was detected in Dogo variety and 0.03mg/kg for LD-88 variety. The highest leaf relative water content (LRWC) were recorded for Dogo and LD-88 okra varieties (70.4% and 73.5%) respectively while the lowest value was found in the control plants. Hazard quotient increased with increased contamination hence, the need for integrated health risk assessment for inhabitants of areas polluted with such contaminants. Heavy metals of lead and cadmium uptake by okra in this study was not at critical levels, however, their continuous intake may pose danger to human health.
Keywords: *Bioaccumulation, Spent lubrication oil, Heavy metals, Contamination, Okra varieties*

INTRODUCTION
Okra *(Abelmoschus esculentus (L.) Moench*) is an erect, semi-woody herbaceous annual, which is highly variable in growth from less than 1m to over 3m in height. The leaves and fruits of okra plant are mostly eaten fresh in local communities. The fruits are rich in minerals and vitamins while the stem bark yields fibre (Adetuyi *et al* 2011). Among the environmental pollutants, heavy metals represent a significant hazard to the environment, being both an ecological and health risk. The use of fertilizers and pesticides on agricultural farms can be one of the sources for heavy metals contamination in rural areas. These metals are highly persistent and not biodegradable contaminants, therefore, they accumulate in soil, then becoming accessible to plants or leaching to groundwater (Ahmed *et al*, 2019), the presence of these metals in soil raises a concern for crop growth and food security (Khaled, and Muhammad, 2016, Chioma *et al* 2014). Plants grown on soils contaminated with oil usually exhibit with symptoms of metal phytotoxicity resulting in poor growth and yield (Sajjad, *et al*, 2009). In addition, some

plant species are tolerant to heavy metal stress, showing little inhibition or damage and can accumulate high concentrations of the metals in their tissues (Ahmed *et al*, 2019). Some plants tolerate elevated concentration of heavy metals in soil and can easily bioaccumulate these metals hence pose a health risk to animals and humans. This is because the metals can be easily transferred to consumers through food supply and consequently causes health problems (Fernando, 2012, Matthews-amune, 2018). As a result, human health risk from heavy metal bioaccumulation in vegetables has become a subject of growing concern in recent years (Adewuyi, and Opasina, 2010, Deribachew, *et al* 2015). The objectives of this study is therefore to assess the bioaccumulation and translocation factors of lead and cadmium in okra varieties grown on contaminated soil and assess their health implications on consumers at large.

MATERIALS

Okra
Mesh (2mm)
Lubricating oil
Lead (Pb)
Cadmium (Cd)

METHODS

Experimental site and condition

The study was conducted at the Teaching and Research Farm of the Federal Polytechnic, Ado-Ekiti located in the derived savanna zone of Nigeria. The screen house experiment was carried out to assess the bioaccumulation of Lead (Pb) and Cadmium (Cd) levels on Physiological and Agronomic performance of two okra (*Abelmoschus esculentus* L. (Moench) varieties grown on soil contaminated with spent lubricating oil. The experiment was a 2 x 5 factorial scheme of 2 okra varieties and 5 different rates of spent lubricating oil arranged in a Completely Randomized Design (CRD) with three replicates. In this experiment, 40 plastic containers of 7 litre capacity were perforated at the bottom and filled with top soil obtained from the nursery site of the Department. The soil was sieved to remove gravel and debris with a 2mm mesh. 5 seeds each of the two okra varieties were planted per hole and later thinned to two after percentage germination was performed. The two okra varieties used for this experiment were (i) Dogo (an indigenous variety) and LD-88 (an improved variety) while the treatments consisted of T0: 0 ml, T1: 10 ml, T2: 15 ml, T3: 20 ml, T4: 25 ml (w/v).

Source of Experimental Materials and Treatments

The seeds of the two okra varieties used for the study, namely. (i) Dogo (an indigenous variety) and LD-88 (an improved variety) were obtained from the National Institute of Horticulture (NIHORT), Ibadan while the spent lubricating oil was obtained from auto-mechanics workshop in Ado-Ekiti. The soil was treated with the spent lubricating oil to achieve T0: 0 ml, T1: 5ml, T2: 10 ml, T3: 15 ml, T4: 20 ml % v/w (volume of oil, weight of soil) according to the method of Adenipekun and Kassim (2006). The mixing was gradually done to ensure thorough and even mixing while the untreated soil (0% oil) served as control. The soils were watered to 60% field capacity. Two seeds of each okra variety were planted in the 7 litre plastic containers now a mixture of oil and top soil in their different proportions. Watering was done each day in the morning. The plants were harvested eight weeks after planting to allow for bioaccumulation of heavy metals in the root, leaf and fruit of okra while the roots, leaf and fruits were analyzed for lead and cadmium bioaccumulation for each of the tested varieties.

Plant growth measurements

Germination (%) records were taken at commencement of germination for up to15 days after sowing and okra seeds which failed to sprout after that time were regarded as dead. The height of each plant was measured at regular interval of seven days from the soil level to the terminal bud using a meter rule (Odjegba & Sadiq, 2002). The leaf area was determined by measuring the base, the middle and the upper part of leaf with a ruler and calculated using the formula breadth x length x 0.85 and the girth was taken 2cm above the soil level; the same point was maintained till the end of the experiment to ensure accurate reading, using Vernier calipers.

Determination of Total Leaf chlorophyll content:

Total chlorophyll content was estimated according to the spectrometry methods. The 100 mg fresh leaf was crushed in 20 ml of 80% acetone and the extract centrifuged for 10 min at 1000 rpm. Absorbance of the supernatant was recorded at 663nm and 645nm. They were read using a spectrophotometer. Chlorophyll content (expressed as mg/g-1 of each sample) was estimated according to the formula as follows: Chlorophyll a (mg/g-1) = 12.7 (A663) – 2.69 (A645) x VW Chlorophyll b (mg/g-1) = 22.9 (A645) – 4.86 (A663) x VW Total Chlorophyll t (mg/g-1) = [20.2 (A645) – 8.02 (A663) xVW]/1000 Where A = absorbance at the given wavelength, W = weight of fresh leaf sample, V = final volume of chlorophyll solution (Li *et al*., 2018, Oyewusi *et al*,2021).

Determination of Leaf Relative Water Content (LRWC):

Fresh leaf samples were collected from each treatment. A sharp cork borer was used to cut the leaf samples into small discs (5cm diameter). These were weighed and recorded as sample fresh weight (W), after which the samples were hydrated to full turgidity in distilled water for four (4) hours under normal room light and temperature. After 4 h, the samples were taken out of water and quickly dried of any surface moisture using filter paper, and immediately weighed to obtain full turgid weight (TW). Samples were then oven dried at 80^0c for 24 hrs and allowed to cool in desiccators, and weighed to determine the dry weight (DW). Relative water content was calculated using the mathematical expression below:

$$LRWC (\%) = \frac{W - DW}{TW - DW} \times 100$$

Where:
W = sample fresh weight
TW = sample turgid weight
DW = Sample dry weight (Oyewusi *et al;* 2020)

Determination of lead and cadmium concentrations

Lead and Cadmium concentrations were carried out on plant leaves, roots and fruit. 2g of pulverized sample was put into a conical flask. 10ml of HNO3 was added, and then the mixture was boiled with steady heat till it almost dried. This was allowed to cool before 50 ml distilled water was added and boiled for 10 minutes. Mixture was allowed to cool again and then filtered. The mixture was made up to a known volume. Heavy metal analysis was done using Atomic Absorption Spectrophotometer Buck Scientific 210 VGP model. The instrument was first calibrated with already prepared working standard of corresponding elements to be analyzed after which the concentration of the element in each sample was determined.

$$\textbf{Conc. mg/kg} = \frac{\textbf{AAS Reading x Dilution Factor}}{\textbf{Weight of Sample}}$$

Lead and cadmium concentrations were then measured using an Atomic Absorption Spectrophotometer (Bulk Scientific, Model 210 VGP).

Bioaccumulation Factor (BAF): ratio of metal concentration in okra fruit to metal concentration in the soil)
Translocation Factor (TF): ratio of metal concentration in leaf to metal concentration in the root) was calculated to further assess heavy metal accumulation potential of the two okra varieties and the consequent health implication.

$$BAF = \frac{\text{Concentration of metal in fruit}}{\text{Concentration of metal in the soil}}$$

$$TF = \frac{\text{Concentration of metal in plant leaf}}{\text{Concentration of metal in the root}}$$

The germination percentage (PG) was calculated as follows:

$$Germination\ Percent(\%) = \frac{Number\ of\ seed\ that\ germinated}{Number\ of\ seed\ that\ was\ planted} \times 100$$

The rate of flower abortion will also be examined as follows;

$$\text{Rate of flower abortion (\%)} = \frac{\text{Total number of flowers} - \text{Total number of pods}}{\text{Total number of flowers}} \times 100$$

Data Collection and Analysis

Data collection on growth and yield parameters commenced from the first week after planting. Data were collected on days to emergence and % germination percentage**,** leaf relative water content, leaf chlorophyll content**,** leaf area **,** plant height, number of leaves and branches**,** days to first flowering, number of flowers per plant, rate of flower abortion, pod number, pod diameter, pod length, 100 seed weight and Pod weight

Data collected were subjected to One-way analysis of variance (ANOVA) and Duncan Multiple Range (DMR) Test to establish the mean differences at 5% level of probability, using SPSS Version 16.0. Mean, Standard Deviation, and Coefficient of Variability were also used to compare the degree for each variation of each treatment

RESULT AND DISCUSSION

Table 1: Properties of soil before contamination with spent lubricating oil

Properties	Value
Ph (water) %	4.16
Total N (%)	0.10
Available P (mg/kg)	12.76
Ca^{2+} (Cmol/kg)	1.80
Mg^{2+} (Cmol/kg)	0.70
K^{+} (mg/kg)	0.14
Na^{2+} (Cmol/kg)	0.22

Organic carbon (%)	0.78
Organic matter (%)	1.35
Particle size distribution	-
Sand	56.80
Silt	20.00
Clay	23.20
Total porosity (g/g)	35.30
Water holding capacity (g/g)	0.061
Texture	Sandy loam
Bulk density)g/cm^3)	1.32
Property of Spent lubricating oil	
Lead (mg/kg)	39.75
Cadmium (mg/kg)	10.56
Organic carbon (%)	17.30
Zinc (mg/kg)	19.30
Available P (mg/kg)	0.02
Nitrogen (%)	6.80

Table 1 showed the result of soil chemical properties before the experiment. The pH of the soil was 4.16 which is acidic. Organic matter contents analyzed was 1.35%. Nitrogen content was low 0.10 g/kg. The available P content in the soil was low 4.16 mg/kg, K was also low (0.14 cmol/kg), Na (0.22 cmol/kg), Ca (1.80cmol/kg) and Mg (0.70 cmol/kg).The result showed that the soil was sandy loam in texture with high proportion of sand (56.80%). This implies that basic cations such as Ca, K, Na and Mg would be leached more easily as texture determines the degree of retention or ease of leaching of basic cations (Wapa and Oyetayo, 2014). Heavy metals concentration in spent engine oil (Table 1) indicated that the values of Zn, Pb, Cu and Cd were within normal safe range in soils The percentage organic carbon and nitrogen were respectively high Available phosphorus was very low.

Table 2: Assessment of Lead (Pb) and Cadmium (Cd) Bioaccumulation on Germination perrcentage and Mean Germination Time (GMT) of two okra varieties grown on soil contaminated with spent lubricating oil

Treatment	Variety	Number of seeds planted	Number of seeds germinated	Percentage germination (%)	MGT In Days	MGT in hours
0ml	Dogo	5.0	5.0	100	5.0	120
	LD-88	5.0	5.0	100	5.0	120
5ml	Dogo	5.0	5.0	100	6.0	144
	LD-88	5.0	5.0	100	6.0	144
10ml	Dogo	5.0	4.0	80	8.0	192
	LD-88	5.0	4.0	80	8.0	192
15ml	Dogo	5.0	3.0	60	9.0	216
	LD-88	5.0	3.0	60	9.0	216
20ml	Dogo	5.0	1.0	20	13.0	312
	LD-88	5.0	1.0	20	13.0	312

The result in Table 2 shows that all the seeds germinated on soil contaminated with spent lubricating oil for both okra varieties and for the 5ml treatment. Conversely, there was a progressive decline in the percentage germination and the mean germination time for okra seeds treated with 10ml, 15ml and 20mls of spent lubricating oil for both varieties. At 20ml contaminated soil, only 20% of okra seeds germinated with a MGT of 13 days before emergence for both varieties. This shows that the higher the concentration of SLO in the soil, the lower the rate of germination for all the tested okra varieties.

Table 3: Assessment of Lead (Pb) and Cadmium (Cd) Bioaccumulation on growth and growth characters of two okra varieties grown on soil contaminated with spent lubricating oil at harvest

Treatments	Variety	Plant height (cm)	Number of leaves	Number of branches	Stem girth (cm)	Leaf area (m^2)
0ml	Dogo	118.0^{a}	49.0^{a}	6.0^{b}	3.9^{a}	64.2^{b}
	LD-88	78.9^{g}	39.9^{c}	8.1^{a}	3.8^{a}	67.4^{a}
5ml	Dogo	109.1^{b}	42.6^{b}	6.4^{b}	3.7^{a}	61.6^{c}
	LD-88	71.8^{f}	33.5^{d}	8.3^{a}	3.7^{a}	67.3^{a}
10ml	Dogo	101.4^{c}	38.4^{c}	6.5^{b}	3.5^{a}	57.5^{d}
	LD-88	67.8^{h}	31.5^{d}	8.9^{a}	3.4^{a}	61.9^{c}
15ml	Dogo	93.5^{d}	35.1^{d}	5.5^{b}	3.5^{a}	52.9^{d}
	LD-88	61.2^{i}	30.0^{e}	6.3^{b}	3.2^{a}	55.7^{d}
20ml	Dogo	84.6^{e}	31.0^{e}	5.0^{b}	3.5^{a}	50.0^{e}
	LD-88	60.5^{i}	29.7^{e}	6.8^{b}	3.1^{a}	49.6^{e}
SE±		6.08	2.31	0.37	0.05	1.95
SD		19.2	7.29	1.18	0.16	6.16
CV		0.23	2.31	0.17	0.04	0.10

Mean followed by the same superscript significantly different at 0.05% probability on the same row using Duncan's Multiple Test (DMRT)

The result in Table 3 shows that LD-88 performed significantly better for most of the measured growth characters over the Indigenous Dogo variety. The result also indicated that growth characters of plant height, number of leaves and branches and leaf area development were significantly higher at 0ml control, Lower values were however recorded for both okra varieties at higher concentrations of SLO. The result also shows that there was no significant difference in stem girth of okra grown on soil contaminated with SLO while at 20ml contamination, significantly lower values were obtained

Table 4: Assessment of Lead (Pb) and Cadmium (Cd) Bioaccumulation on yield and yield characters of two okra varieties grown on soil contaminated with spent lubricating oil at harvest

Treatments	Variety	Days to First Flowering	Number of flower/plant	% Rate of Flower abortion/plant	Number of pods/plant	Pod Length (cm)	100 seed weight (g)	Fresh Pod yield (t/ha)
0ml	Dogo	39.0^{d}	12.0^{a}	16.7^{d}	10.0^{a}	10.9^{a}	6.8^{a}	2.67^{b}
	LD-88	37.7^{d}	13.0^{a}	15.4^{d}	11.0^{a}	11.0^{a}	6.2^{a}	3.09^{a}
5ml	Dogo	44.8^{c}	10.6^{b}	33.0^{c}	7.1^{b}	10.2^{a}	6.3^{a}	2.60^{b}
	LD-88	40.5^{c}	11.0^{a}	27.3^{c}	8.0^{b}	10.5^{a}	6.5^{a}	2.70^{a}
10ml	Dogo	49.6^{b}	11.8^{a}	40.7^{c}	7.0^{b}	10.0^{a}	5.8^{a}	2.01^{a}
	LD-88	44.0^{c}	11.0^{a}	36.4^{c}	7.0^{b}	10.1^{a}	5.9^{a}	2.03^{a}
15ml	Dogo	53.1^{ab}	10.5^{a}	100^{a}	-	-	-	-
	LD-88	47.8^{b}	11.7^{a}	100^{a}	-	-	-	-
20ml	Dogo	58.0^{a}	8.0^{a}	100^{a}	-	-	-	-
	LD-88	50.9^{b}	9.0^{a}	100^{a}	-	-	-	-
			1.94	11.38	0.26	11.10	0.66	0.28
SE±			6.14	35.96	3.58	3.51	2.07	0.89
SD			0.13	0.63	0/83	0.56	0.52	0.56
CV								

Mean followed by the same superscript significantly different at 0.05% probability on the same row using Duncan's Multiple Test (DMRT)

The result on yield and yield characters shows that days to first flowering were significantly shorter under the 0ml control over other treatments for both okra varieties. Conversely, the more the concentration of SLO in the soil, the longer it took both okra varieties to flower. It took longer days to attain first flowering at 20ml in contaminated soil. For instance, it took Dogo okra variety 58 days while LD-88 days attained first flowering after 51 days. Similarly, number of flower per plant were significantly lower at 20ml concentration while rate of flower abortion was significantly lower at 0ml control and 5ml. Total flower abortion was recorded at 15ml and 20ml for both okra varieties. There was no result recorded for number of pods/plant, pod length, 100 seed weight and fresh pod yield at 15ml and 20ml concentration of SLO for both okra varieties indicating a physiological barrier of okra to production.

Table 5: Assessment of lead (Pb) and Cadmium (Cd) Bioaccumulation on leaf and pod yield of two okra varieties at harvest

Treatments	Variety	Okra used	Parts	Conc of Lead (Pb) mg/kg	Conc of Cadmium (Cd) mg/kg
0ml	Dogo	Leaf		ND	ND
		Pod		ND	ND
	LD-88	Leaf		ND	ND
		Pod		ND	ND
5ml	Dogo	Leaf		Trace	Trace
		Pod		Trace	Trace
	LD-88	Leaf		Trace	Trace
		Pod		Trace	Trace
10ml	Dogo	Leaf		0.04	Trace
		Pod		0.03	Trace
	LD-88	Leaf		0.04	Trace
		Pod		0.03	Trace
15ML	Dogo	Leaf		0.04	0.01
		Pod		0.05	0.01
	LD-88	Leaf		0.06	0.02
		Pod		0.06	0.02
20ML	Dogo	Leaf		0.06	0.02
		Pod		0.06	0.02
	LD-88	Leaf		0.19	0.03
		Pod		0.07	0.03

ND-Not Detected

Assessment of lead (Pb) and Cadmium (Cd) Bioaccumulation on leaf and pod yield of two okra varieties at harvest is presented in Table 5. The result shows that at 0ml control, there was no detection of any traces of Pb and Cd presence in the leaf and pod of the two okra varieties while at 5ml concentration, there was only a trace of the metals detected in the leaf and pods of okra. At 10ml concentration, there was only a trace of Cadmium detected while 0.04mg/kg of lead was detected in Dogo variety and 0.03 for LD-88 variety. Higher detection at 15ml and 20ml contamination was recorded at for both varieties.

Table 6: Assessment of lead (Pb) and Cadmium (Cd) Bioaccumulation on Leaf Relative Water Content and Chlorophyll concentration of two okra varieties

Treatments	Variety	LRWC	CHL Conc	BAF	TF
0ml	Dogo	(%) 70.4	(Mg/100g 15mg/l	-	-
	LD-88	73.5	16mg/l	-	-
5ml	Dogo	60.9	13.mg/l	-	-
	LD-88	64.6	14.mg/l	-	-
10ml	Dogo	40.7	5.mg/l	-	-
	LD-88	43.9	7.mg/l	-	-
15ml	Dogo	28.9	-	Trace	Trace

	LD-88	33.0	-	Trace	Trace
20ml	Dogo	25.0	-	Trace	Trace
	LD-88	18.9	-	Trace	Trace

LRWC-Leaf Relative Water Content, Chlorophyll Concentration, BAF-Bioaccumulation Factor, TF-Translocation Factor.

The result in Table 6 revealed that LRWC and Chlorophyll concentration was significantly higher at 0ml control for both varieties while at 5ml contamination, LD-88 had higher LRWC and Chlorophyll concentration (64.6%, 14mg/l) over Dogo variety (60.9%, 13mg/l) respectively. Similarly, significantly lower values of LRWC and Chlorophyll concentration was recorded at higher contamination for both varieties. At 15ml and 20ml contamination over the 0ml control. The result revealed that the Chlorophyll concentration was denatured at 15ml and 20ml contamination while the BAF and TF was significantly low and detected as trace. At higher concentrations of oil in soils, most plant species suffers serious depression in growth. This has been attributed to poor soil conditions, dehydration and impaired nutrient uptake by the roots even when they are present, they are not usually in the absorbable form (ions) rather they are present as compounds. In this study, germination of Okra plants was mostly delayed in the soils contaminated with spent lubricating oil, and this effect varied with different oil concentration. About 80% of all the seeds of the two okra varieties failed to germinate at 20ml of contaminated soils and germination only occurred about 13 days after planting. The presence of SLO in the soil-plant microenvironment appears to have affected normal soil chemistry and this inhibited nutrient release and uptake as well as amount of water imbibed **(**Ayub, et al, 2016). The decrease in height of plant with increase in concentration of SLO is probably due to the non-availability of adequate water, as a result of blockage of soil pore spaces thereby affecting infiltration and easy movement of water molecules in and out of the soil pore spaces. This subsequently affected nutrient uptake and mobility. Nevertheless, the growth of the tested okra plants were not significantly affected at lower concentrations as was observed in the 0ml control and at lower 5ml contamination. This implies that okra can tolerate low levels of SLO contaminations. Mohammed and Folorunsho (2015), Matthews-amune et al (2018), Ruqia *et al*., (2015) and Rumteke *et al* (2016**)** discovered that some heavy metals at low concentrations are essential micro-nutrients for plants, but at high concentrations, they may cause metabolic disorders and growth inhibition for most of the plant species. The poor growth performance recorded in soils contaminated with higher amounts of SLO correlated to the level of the leaf relative water contents (LRWC) recorded. The LRWCs of the plants grown in SLO contaminated soils were highly reduced. This translated into low metabolic processes in those plants which affected their growth performance. Mahmood, et al (2019) made similar observations on *Chromolaena odorata* grown in soil treated with crude oil. The SEO treatment had adverse effect on chlorophyll synthesis.

CONCLUSION

SLO affected the growth of the two okra varieties grown on contaminated soil by causing a significant reduction in most of the measured growth and yield parameters as well as contaminating the plants with heavy metals of lead and Cadmium at different concentrations. Hazard quotient increased with increased contamination hence, the need for integrated health risk assessment for inhabitants of areas polluted with such contaminants. This investigation shows that spent lubricating oil pollution has potential adverse effects on Okra plants, though plants can tolerate low levels of contamination at 5ml, hence, appropriate disposal of SLO should be taken seriously by those handling it. Heavy metals of lead and cadmium uptake by okra in this study was not at critical levels, however, their continuous intake may pose danger to human health.

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ISOLATION, IDENTIFICATION AND PATHOGENICITY OF FUNGI ASSOCIATED WITH COCOYAM CORM (*COLOCASIA ESCULENTA*) SPOILAGE IN IKWUANO LOCAL GOVERNMENT, ABIA STATE.

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ABSTRACT
Cocoyam (Colocasia esculenta) corms, purchased from local markets (Amawom and Ndoro) in Abia state, showing spoilage symptoms were examined for rot associated with fungal pathogens. The causatives microorganisms were isolated from the corms by plating the spoilt tissues obtained aseptically onto Potato dextrose agar media supplemented with lactic acid as an antibacterial agent. After four days incubation, the developing mycelia were purified by repeated sub culturing and identified macroscopically and microscopically using the slide culture technique. The organisms recovered from spoilt Cocoyam were Aspergillus niger, Fusarium oxysporium, Botryodiplodia theobromae, Penicillium chrysogenum and Mucur circinelloides. The rot caused due to B. theobromae, M. circinelloides and A. niger were extensive resulting in complete damaging of Cocoyam tissues. A. niger had the highest percentage occurrence ((28.05%) while P. chrysogenum had the least percentage occurrence of (10.00%).The Pathogenicity revealed that all the isolated fungi can elicit infection but at different degree levels. These fungi might have gained entrance into these Corms from the field, wounds during harvest and transportation. It could also be from the store house (Storage). Proper agronomics activities should be carried out on the field to guide against pathogen infestation on the field. Also, proper care should be taken to guide against bruises during harvesting and transportation of these products. All the above precautions should be taken into consideration as some of these spoilage fungi are known to have negative effects on both humans and livestock because they produce mycotoxins.
Keywords: *Pathogenicity, Fungi, mycotoxins, Colocasia esculenta, harvesting.*

INTRODUCTION
Cocoyam is a perennial monocotyledonous herbaceous plant. It consists of a central corm from which cormels, roots and shoots arise (Onwueme, 1978) Each leaf consist of a long erect petiole and large lamina (Williams *et al*., 1982). Edible cocoyam cocoyam (*Colocasia esculenta*) is a major stable carbohydrates food in sub-saharan Africa It is nutritionally superior to other root and tubers in terms of digestible crude protein and minerals like Ca, Mg and P contents (Green, 2003). Cocoyam took the third place out of the most important root and tuber family cultivated in Nigeria after Yam and Cassava (Igbozulike, 2015). It can be used as an anti-poisoning and wound healing agents by applying the fresh mash in the sores opening. Cocoyam is consumed by both humans and animals and equally useful in industries as raw materials. The oxalic acid content in cocoyam made it dangerous to consume raw for animals and humans because of its itching ability. Spoilage of Cocoyam corms through fungi attack leading to loss in quality and quantity of the corms is one of the major problems of Cocoyam production in Nigeria (NRCRI, 2008) Other problems associated include mechanical, physiological, rodents, birds which always resulted into fungal rot (FAOSTAT, 2019). Post-Harvest loss of root and tuber crops has been a very serious problem to farmers as more than 40% of their harvest are lost because of fungal rot. (Olurinola *et al.*, 1992. This study focuses on isolation and identifying Fungi responsible for Cocoyam spoilage.

MATERIALS AND METHODS
Experimental Site
The study was carried out at the Plant Protection Laboratory, National Root Crops Research Institute, Umudike, Abia State, Nigeria.

Collection of Infected Coccoyam Corms
Infected and clean (non infected) corms of cocoyam showing disease symptoms of soft and dry rots were obtained from two local markets (Ndoro and Amawom) in Ikwuano local government in Abia State. The infected corms

were packaged in different sterile polyethylene bags, taken to the laboratory for isolation and identification of pathogens.

Sterilization of Materials

All glassware used in this study were washed with detergent, rinsed, dried and sterilized by autoclaving at a temperature of 121ºC for 15min. The scalpel, cork borer and inoculating needle were sterilized by dipping them in 70% ethanol and passing them over a Bunsen burner flame until red hot.

Isolation of Fungi

The isolation technique used by Ogbo and Agu (2015) was used in this study. A small section of the cocoyam tissue showing advancing margin of rot and adjoining healthy tissue were cut using sterilized scalpel whose surface were sterilized with 70% ethanol and flamed to red hot. The cut pieces were soaked/washed in 70% ethanol for 1min for surface sterilization. The pieces (1mm-2mm) were then rinsed in three successive changes of sterile distilled water (Frank and Kingsley (2014). The cocoyam pieces were placed on sterile paper towels in the laminar Air flow cabinet to dry for 15 minutes.

Inoculation

The dried infected tissues were aseptically plated onto Petri dishes containing acidified sterile solidified potato dextrose agar (PDA) with the aid of sterile forceps and the plates were incubated at room temperature $\pm$27ºC for 5 days. Fungi associated with the cocoyam rot affected tissue were observed and the frequency of isolation determined using method of Okigbo (2003). Sub-culturing was done to obtained pure cultures of the isolates.

Identification of Fungal Isolates

Pure colonies growing on the plates were identified macroscopically and microscopically. Features observed were colony colour, type of hyphae, texture, shape and growth pattern. Direct observation of culture under the light microscope by careful preparation of slides stained with cotton blue-in-lactophenol was done.Sporangiophores, septate or non septate mycelia, special features like rhizoid on the fungi isolated are used for identification Detailed drawings of the diagnostic features and identification were noted and compared to existing manual guides according to Burgess *et al.,* (2008).

Pathogenicity Test

Healthy cocoyam corm were washed with running tap water, rinsed in three successive changes of sterile distilled water, thereafter, the corms were disinfected with 70% ethanol for 1min and again rinsed with sterile distilled water 3 times. The tubers were allowed to air dry (10 min). A flamed 5mm cork borer was used to bore hole into healthy cocoyam corm, a 5mm diameter disc from the purified isolate of 5 day old culture was cut and replaced into the hole created in the healthy corm. The same procedure was used for the control except that sterile agar discs were used instead of the place of the purified cultures (inoculum) in the holes created in the corms. The hole was covered with the small tissue of Cocoyam from the bored hole thereafter, Blue Seal Vaseline was used to completely seal the holes to guide against cross contamination (Ogbo and Agu *et al.,*2015). Two whole corms of cocoyam were inoculated per fungus. The inoculated corms were placed in sterile transparent polythene bags whose inside has been moistened with cotton wool soaked in sterile distilled water to maintain a high humidity. The inoculated corms were kept in the laboratory at room temperature for 14 days and assessed for rot development by cutting through the point of inoculation where rots developed .A transparent ruler was used to measure the rotten parts. The pathogens were re-isolated as previously described and their cultural and morphological characteristics were compared with those of the original isolates.

RESULTS

Table1: Frequency of occurrence of fungi isolated from infected Cocoyam corms

FUNGI	% OCCURRENCE
A. Niger	28.05
R.stolonifer	19.05
B.theobromae	20.05
M.circinelloides	23.01
P.chrysogenum	10.00

The fungi that were isolated through colonial morphology and microscopic characteristics from rotten/spoilt cocoyam corm (*Colocassia esculenta*) resulting from the sampling survey above included *Asergillus niger, Rhizopus stotonifer, botryodiplodia theobromae, Mucur circinelloides* and *Pencillium chrysogenum.* The most frequently occurring was *Aspergillus niger* 28.05% while the least occurring was *Pencillium sp.*10.00% (Table 1) above.

Table 2: Percentage occurrence of isolated pathogenic fungi

Organisms	Percentage Rot (%)
Aspergillus niger	73.00
Rhizopus stolonifer	55.00
Botryodiplodia sp	79.00
Mucur circinelloides	21.00

The fungi tested for Pathogenicity includes A. *niger*, *R. stolonifer*, *B. theobromae and Mucur circinelloides and* were confirmed to cause the similar disease and rot type noticed on the rot infected sample. The result showed that *Mucur circinelloides incited* dry rot at a lower rate (21.00%). The fungus *Botryodiplodia sp* was the predominant, causing 79% soft rot on the *colocassia esculenta.*

Table 3. Frequency of Occurrence of the different Disease Conditions

Disease Conditions	Frequency of Occurrence	% Occurrence
Dry rot	2	22.2
Soft rot	7	77.7
Total	9	100

Table 3 records the frequency of occurrence of the different disease conditions. Dry rot had 22.2% occurrence while soft rot had 77.7 percentage occurrence. The soft rot symptoms showed brownish liquid and soft cocoyam tissues with offensive odour while the dry rot revealed brown dry hard tissue.

DISCUSSION

Fungal pathogens are the major causative agents of rot in root and tuber crops, reducing the yield, and quality per annum (IITA, 1985). The fungal organisms indicated in this study for causing cocoyam rot were *Botryodiplodia theobramae, Aspergillus niger, Rhizopus stolonifer* and *Mucur spp* (Anukworji, *et al*., 2012 and IITA, 1985). These organisms were responsible for cocoyam corm rot in the store and equally in the soil on the field. The pathogenicity test showed that the inoculated fungi causes rot on the cocoyam corm; this was due to the ability of the pathogenic fungi to utilize the tissues of cocoyam corm as nutrients aiding its growth and development. This result is similar to the fungi associated with Nigeria cocoyam (Igbozulike, 2015). Okigbo, (2003) also isolated *Aspergillus niger* and *Fusarium* from spoilt Cocoyam .Onuegbu, (1999) equally isolated *B.theobromae* and *Mucur* species which belong to the group of fast growing fungi that causes rot in Cocoyam. Most recent work of Frank and Kingsley (2014) revealed that *Mucur sp, Aspergillus sp* and *Fusarium sp* out of the five isolated in this study are actual pathogens of root and tuber crops. In this study, most of these fungi tend to cause severe rot in cocoyam production as observed during the pathogenicity test. The infestation of these crops started from the field and later to the storage barn. Healthy planting materials plus clean planting equipment should be used while planting. Injuries should be avoided during harvesting to avoid direct penetration of these pathogenic organisms. Proper temperature and relative humidity should be maintained during storage, because these factors also aid the proliferation of these pathogenic fungi. .All the fungi isolated in this study has also been prove by other research workers (Anukworji *et al.*, 2012,Onuegbu, 1999 and Okigbo, 2003) to be cause of fungal rot in storage of root and tuber crops. *Aspergillus niger* and *Botryodiplodia* are responsible for dry rot while wet rot was caused by *Mucur sp* and *Rhizopus sp.*

CONCLUSION

Cocoyam, a staple crop for human consumption, livestock feeds and industrial uses should be protected against fungal attack due to its importance .Due to being a source of revenue for farmers and the nation Anukworji *et al.*, 2012 ,the crop should be protected against fungal infestation by encouraging farmers to adopt proper agronomics practices to guide against fungi infestation, care should be taken during harvesting and transportation to guide against bruises so as to ensure a healthy nation and in turn have a balanced economy.

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PERFORMANCE OF SOME SUGARCANE (*SACCHARUM OFFICINARUM*) ACCESSIONS FOR RESISTANCE TO SMUT DISEASE AT BADEGGI, NIGERIA

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ABSTRACT
There is need for continuous assessment and development of smut resistant sugarcane varieties as the sugar estates in Nigeria depends more on exotic cultivars that succumb to pests/diseases and suffer quick yield decline due to non-adaptability in their new environment. A study was conducted to assess the performance of thirty five sugarcane accession under smut infestation at NCRI Badeggi. The clones were planted on Randomized Complete Block Design (RCBD) with three replications. Analysis of variance reveals significant differences among the clones for some traits. Highest cane yield (112.80, 111.10 and 104.43 t/ha) were recorded in NCS-009, NCS-003 and NCS-002 for the plant crop. Maximum cane yield for the ratooned crop was observed in NCS-002 (74.43 t/h) which was significantly heavier than the yield documented for many of the studied accessions except for NCS-003, DB75159, NCS-001, B-2, NCS-009 and B 245/B0197. Generally, there was a noticeable yield decline in the ratoon crop of the studied accessions except for B881602 and DB75159 that deviate from the aforementioned trend. The best brix of 23.00% was recorded for Cp72-2086-1 in the plant crop, while BR 971007 and Cp72-2086-1 having the best brix mean value of 23.87 and 23.70 % in the ratooned crop. NCS-002, NCS-007, KNB9218, NCS-003, DB75159, BR971007 and B 245/B0197 proved to be highly resistant to smut infestation during the plant crop in the year 2019 and the ratooned of sugarcanes accessions in year 2020 reveals that NCS-002 was highly resistant to smut and NCS-007, KNB9218, B51410, NCS-003, DB75159, NCS-009 were also resistant to the disease. This evaluation has revealed the potential of some sugarcane accessions and their reaction to smut disease for subsequent utilization in the breeding program.
Keywords: *Smut, accession, resistant, susceptible*

INTRODUCTION
Sugarcane (*Saccharum* spp.) is one of the most important grass species cultivated in the tropics and subtropics (Solomon *et al*., 2019). It belongs to the genus *Saccharum* of the family Poaceae. The crop is recently been used for wide range of value-added products that go beyond food, such as bioethanol, bioelectricity, biohydrocarbons and biochemicals. It contributes about 75% of world sugar production with sugar beet producing the rest (Mani *et al*., 2019). Sugarcane is an important industrial cash crop in Nigeria (Olaoye, 2006) and its cultivation is very useful as it has numerous products and contributes to the national economy greatly.

Sugarcane whip smut (*Sporisorium scitaminea*) is a very destructive disease in all sugarcane growing areas of the world including Nigeria (Sarmad, 2016; Wada *et al*., 2016). It was first reported from Natal, South Africa in 1877 and for many years were mainly restricted to the old World, where it caused repeated outbreaks (Mohammed, 2016). According to Mohammed (2016), the disease was first noted on *Saccharum sinense* and till today it is still the most devastating fungal disease problem in many African sugarcane plantations and is often a serious menace in sugarcane growing areas. It is a serious disease of sugarcane which causes significant quantitative and qualitative loses to cane farmers worldwide. According to Braithwaite *et al.* (2008) yield losses may be 39-56 percent in planted crop and 52-73 percent in ratoon crop. The best eco-friendly and most sustainable means to contain the pathogen are through the use of resistant varieties (Sundravadana *et al.,* 2011; Philip *et al*., 2010).

Evaluation and screening for promising smut resistance clones from diverse sugarcane germplasms to serve as parent in hybridization programmes which shall result in development of smut resistant and high quality varieties is paramount.

Different sugarcane clones exist and are grown by farmers worldwide and efforts have been made by scientists in Nigeria to collect, evaluate and screen these germplasm for yield performance and also for sources of diseases and pest resistance in the existing collections. However due to varietal degeneration and changes in smut races, it has become paramount for continuous hybridization activities to generate smut resistance genotypes that will replace any obsolete clone. Variety resistance is retained for few years, while a known resistant variety may succumb to a new physiological strain (race) of smut with changes in climatic conditions (Mansoor *et al*., 2016). The diseases resistant germplasm of sugarcane plays a leading role for assessment of resistant varieties through breeding program (Begum *et al*., 2007). Resistant genotypes of sugarcane could play a vital role in reducing the yield loss caused by the disease. It has been evidence that selection of resistant parents for hybridization programmes would improve the level of resistance of progenies (Glyn, 2004). Therefore, screening of sugarcane genotypes against smut disease is a pre-requisite in the varietal development activities before hybridization and releasing varieties for commercial purposes.

MATERIALS AND METHODS

The experiment was conducted at the sugarcane research field of National Cereals Research Institute (NCRI) Badeggi (Lat 9° 3' 0"N, Long 6° 9' 0"E and 70.5m above sea level), Niger state. Thirty five sugarcane accessions were sourced from the National Sugarcane Germplasm at NCRI, Badeggi.

The sugarcane accessions were used as the experimental treatments. The experiment was conducted in a randomized complete block design with three replications.

Fresh smut whips were collected from smut affected plants grown at NCRI sugarcane field. The teliospores were gently scraped and thoroughly sieved, using 53 µm mesh. The sieved teliospores were sealed in cellophane bags and stored in the refrigerator at 10°C. Viability of inoculum was confirmed on water agar and those that reveal viability of >70% were taken for preparation of inoculum suspension. Four grams of spores were added in 1 litre of distilled water along with a few drops of Tween 20 for homogenous spore suspension. Finally, the inoculum density was adjusted to 4×10^6 spores/ml with the help of haemocytometer (Nasr, 1977). The planting materials (setts) were completely immersed into the smut inoculum for an hour. The setts were then be removed and put into a sack under shade for 14 hours prior to planting. Ten inoculated setts was planted (lay end to end) per row at a depth of 6-7cm and covered with top soil. The stalks were cut into 3 budded setts and grown on a single row of 5m long with inter row spacing of one meter. The experiment covers a total area of 18m x 34m ($612m^2$). The plant crop was established on 11th February 2019 and the accessions were ratooned on 15th January 2020.

Data was collected on sprout (%) count at 21, tiller count at 3 months after planting, plant height at 3 and 6 months after planting, stalk length, Milleable stalk per plot and cane yield ton/ha at maturity. Brix (sugar content) was measured with the aid of refractometer at 12th months after planting. Smut index was expressed by reaction types evaluated with a numerical rating scale of 1-9 where, 1=highly resistant and 9=highly susceptible as described by Satyavir and Beniwal (1978).

The data collected was use for analysis of variance (ANOVA) using Crop Stat package (version 7.2). Means were separated where significant differences occur among the genotypes.

RESULTS AND DISCUSSIONS

There was significant difference among the studied accessions for sprout percent (table 1). D 8687 gave the best sprout percent (67.80%), while accession B 9054 and B-2 has very low sprout performance (16.23 & 24.47%) in their plant crop. However, with the establishment of ratoon crop NCS-009 and NCS-007 show better performance in sprouting (67.67 & 63.33) than all the screened accessions except NCS-002, B85266, BR00001 and B 245/B0197.

NCS-002 possess more tillers in the plant crop which was significantly superior to the number of tillers recorded for some of the studied accessions except NCS-007, B85266, KNB9218, NCS-003, B-2, BBZ951034, SP81-3250, NCS-009, RB86-7512, BR971007, B47419 and B 245/B0197. The ratoon crop result shows that NCS-002 maintain the best in number of tiller and was significantly similar to the number of tillers recorded for NCS-007, B85266, NCS-003, NCS-009, B47419 and B 245/B0197. The lowest mean number of tillers was observed in BOO 270. According to Sharma and Agarwal (1985) good sprouting and tillering with synchronized millable canes of average thickness are desired selection parameters to evaluate the agronomic performance of sugarcane varieties. Diseased plants produced tillers, which some are of no use as the emerging tillers were very weak and later reveal smut whip there by terminating their growth. Sugarcane smut disease had been noted to cause reduction in sprout percentage of sugarcane setts and increase in number of tillers contrary to healthy plants (Ferreira and Comstock, 2001).

The plant height at six months after planting differs significantly among the accessions and KNB9218 poses the maximum (266.67cm) plant height. During the ratoon crop cycle DB75159 has the tallest plant height at six months after planting which does not significantly differs from the plant height documented for NCS-002, KNB9218, NCS-003, NCS-001, SP81-3250, N27, RB86-3129, NCS-006, NCS-009, RB86-7512, NCS-008, BBZ92653 and B 245/B0197.

Table 1: Mean values of growth performance of sugarcane accessions screened for smut resistant at NCRI Badeggi (2019-2020 and 2020/2021)

ACCESSIONS	SPROUT		TILLER		PLH 3 MNT(cm)		PLH 6 MNT(cm)	
	PC	RC	PC	RC	PC	RC	PC	RC
NCS-002	58.90	55.00	26.00	60.67	155.43	174.10	243.43	198.57
NCS-007	41.13	63.33	40.33	57.33	144.20	129.77	221.53	152.10
B 85266	64.47	48.67	29.33	49.33	126.63	134.67	226.43	141.77
B 9054	16.23	28.67	17.00	23.00	141.00	133.13	186.23	136.00
KNB 9218	45.53	34.33	33.67	39.33	163.80	186.90	266.67	188.67
B 51410	41.10	29.33	26.67	26.67	136.77	140.67	220.63	186.30
NCS-003	56.70	42.00	29.00	49.67	165.77	179.20	245.33	207.53
BR 00001	62.20	56.33	22.67	30.67	153.53	166.47	239.53	186.47
BOO 270	42.23	17.67	23.00	7.67	125.43	111.67	226.80	156.00
B 881602	42.23	21.00	15.33	12.67	109.00	117.53	214.57	133.57
DB 75159	34.43	15.00	10.67	19.67	134.90	171.80	235.13	229.10
NCS-001	42.20	32.33	23.00	30.67	145.57	158.00	219.70	194.30
B-2	24.47	33.67	27.33	35.33	134.87	145.43	226.00	184.20
B 96399	34.43	32.67	16.33	13.67	147.00	128.87	225.23	173.53
BBZ 951034	54.47	33.00	28.00	16.67	147.87	137.00	232.23	168.33
SP81-3250	46.70	37.00	38.67	32.33	147.33	161.47	233.37	213.67
D 8687	67.80	29.67	17.00	24.00	166.97	171.23	245.53	219.87
N 27	56.70	36.33	21.00	23.33	146.10	162.10	225.43	200.67
RB 94-2291	44.43	31.67	25.00	22.33	142.77	146.13	244.67	177.90
NCS-005	40.00	28.00	16.00	16.67	148.10	130.57	224.30	185.37
SP71-618	38.90	36.33	22.33	27.67	141.43	142.00	219.77	178.10
RB 86-3129	38.90	29.00	19.00	22.00	160.77	153.33	231.30	227.57
NCS-006	47.80	40.00	24.67	36.00	157.00	156.33	231.30	200.43
NCS-009	57.80	67.67	34.33	44.33	153.87	177.67	250.20	211.43
CP 72-2086-1	35.53	9.00	23.00	9.00	139.00	142.23	226.90	187.00
B 93220	45.53	26.00	25.33	19.00	152.53	132.77	221.33	146.57
RB 86-7512	63.37	30.67	36.00	22.33	165.00	181.33	241.53	199.47
BR 971007	41.10	32.33	27.33	25.33	160.77	151.10	227.77	170.47
BBZ 921101	37.80	31.67	12.00	29.33	157.00	151.30	244.57	173.43
B 47419	41.10	30.67	35.33	34.00	123.00	122.23	218.00	180.57
NCS 008	44.43	51.67	22.00	46.00	188.57	171.20	238.00	209.13
RB 82-5211	45.60	30.33	14.67	24.33	161.77	154.87	228.67	181.70
O535	54.43	38.67	17.33	36.67	136.90	167.20	233.33	175.87
BBZ 92653	63.33	47.33	26.00	39.33	150.77	160.80	249.47	198.67
B 245/B 0197	46.67	51.00	25.67	46.33	152.57	158.20	243.23	192.47
CV %	29.9	33.0	35.1	34.2	11.9	11.9	7.9	13.6
SE $\pm$	7.98	6.83	4.92	5.94	10.20	10.46	10.62	14.49

Note: PC= plant crop, RC = ratooned crop, PLH 3 MNT= plant height at 3 months after planting, PLH 6 MNT= plant height at 6months after planting.

Table 2 reveals significant differences among some sugarcane accession under smut infestation for yield parameters. NCS-003 has more average milleable stalks than all the evaluated entries except NCS-002, NCS-007, KNB9218, N27, RB86-3129, NCS -009 and B 245/B0197. The milleable stalks of ratooned crop was higher in NCS 002 which did not significantly differs with number of milleable stalks recorded for NCS-007, NCS-003, B-2 NCS-003 and B 245/B0197. A very high reduction in number of milleable stalks of ratoon crop was noticed in B85266, Boo 270, B881602, B 96399 and B 93220. Also some of the screened accessions (NCS-002, B-2, SP71-618, NCS-006, NCS-009 and NCS-008) reveal more number of milleable stalks in the ratoon crop above the plant crop. The increment in numbers of tillers at the early stage of growth and the reduction of stalk population during the growth of sugarcane is a characteristic of several gramineous. The phenomenon of cane stalk mortality could be related to the factors which induce competition for growth conditions (light, moisture nutrient) and the survival of the tillers after the competition is a character of a variety (Getaneh *et al.*, 2015). However in this study, the survival of the tillers might also depends on the inherent disease resistance of the accessions and the smut strain pathogen present in the environment.

RB86-3129, NCS-006 and NCS-009 shows longer stalks (236.7, 233.3 and 230.30 cm) in the plant crop result which were at par with stalk length of KNB9218, B881602, NCS-001, B96399, SP81-3250, N27, NCS-005, B93220, BBZ 921101, NCS-008, 0535, BBZ92653 and B 245/B0197. B9054 gave the shortest stalk length

(149.23cm) during the plant crop. The ratoon result reveals that NCS-009 and B 245/B0197 perform better in stalk length (186.10 & 186.0cm), while the shortest stalks were observed in B85266, B51410 and Cp72-2086-1 (107.23, 106.90 & 109.0 cm). There was a general reduction in stalk length of the ratooned crop as against what was observed for plant crop.

Maximum brix of 23.00% was recorded for Cp72-2086-1 which was significantly the same with the brix mean values of B51410, NCS-003, BR00001, RB94-2291, SP71-618, B93220 and BR971007. Many of the studied accessions show increase in brix of the ratooned crop. BR 971007 and Cp72-2086-1 has the best brix mean value of 23.87 and 23.70 %. NCS-006 performs poorly in terms of brix (17.13%) in the ratooned crop. Khan et al., (2017) has also reported differences in brix among some evaluated sugarcane varieties in Ethiopia.

The thirty five studied accessions show highly significant disparities in their cane yield per hectare. Three accessions such as NCS-009, NCS-003 and NCS-002 yielded higher (112.80, 111.10 and 104.43 t/ha) and were better in cane yield than some of the evaluated entries. The lowest cane yield of the plant crop was noted in B881602 (22.57t/ha). Maximum cane yield mean value for the ratooned crop was observed in NCS-002 (74.43 t/h) which was significantly heavier than the yield documented for many of the studied accessions except for NCS-003, DB75159, NCS-001, B-2, NCS-009 and B 245/B0197. The variability observed in cane and other studied traits among the accessions confirm that the accession differs in their genetic makeup of diverse parents. EL-Geddway, *et al*. (2002) stated that sugarcane varieties are greatly affected by genetic makeup. Several authors (Bahadar et al., 2000, Getaneh et al., 2015) had reported variation in cane yield among accessions from diverse parents at different ecologies. According to Keerio et al, (2003) unless the genetic potentialities of a variety are high, mere provisions of growing conditions such as manuring, irrigation etc. will not lead to appreciable improvement in cane or sugar yield.

Generally, there was a noticeable yield decline in the ratoon crop of the studied accessions except for B881602 and DB75159 that deviate from the aforementioned trend. This disease reduces the length and weight of canes (Solomon *et al.,* 2000).

Getaneh et al., (2015) said that the inherent genetic makeup of a variety might have contributed towards higher or lower cane yield and sugar content. They suggested that genetically improved varieties may bear ability to produce satisfactory results for per hectare yield and sugar percentage under given set of environmental conditions.

Table 2: Mean values of yield performance of sugarcane accessions screened for smut resistant at NCRI Badeggi (2019-2020 and 2020/2021)

GENOTYPES	ILEABLE/PLOT		STLK LNT (cm)		BRIX %		YIELD ton/ha		Reaction type to smut	
	PC	RC	PC	RC	PC	RC	PC	RC	PC	RC
NCS-002	40.33	42.67	169.67	148.10	19.07	21.13	104.43	74.43	HR	HR
NCS-007	38.00	36.33	163.67	118.10	18.10	21.23	64.43	43.30	HR	MS
B 85266	30.00	5.00	161.23	107.23	18.90	21.17	56.67	36.67	HS	HS
B 9054	21.00	11.00	149.23	134.10	17.43	19.43	32.23	37.77	R	HS
KNB 9218	41.33	22.33	195.67	159.00	19.20	22.17	74.43	40.00	HR	R
B 51410	23.67	23.00	179.23	106.90	21.50	20.67	39.00	39.97	R	R
NCS-003	44.33	38.00	175.67	158.03	20.93	21.30	111.10	72.03	HR	R
BR 00001	29.00	24.67	190.37	183.47	20.90	22.40	70.00	48.30	S	HS
BOO 270	19.33	6.33	178.90	117.20	17.53	21.67	33.77	25.53	HS	HS
B 881602	13.33	5.33	197.13	130.80	20.13	20.57	22.57	27.77	HS	HS
DB 75159	17.33	17.00	195.00	158.53	20.03	19.77	48.90	54.43	HR	R
NCS-001	23.33	20.67	202.87	154.80	17.30	20.67	62.97	51.10	S	HS
B-2	30.67	38.00	183.67	168.43	18.00	20.57	78.90	52.20	R	MS
B 96399	19.00	9.33	208.87	153.80	19.97	21.20	38.90	18.90	S	HS
BBZ 951034	21.33	10.00	191.23	128.90	15.87	18.00	58.90	39.97	HS	HS
SP81-3250	23.33	22.00	206.67	159.10	19.57	20.70	62.23	38.87	MS	S
D 8687	21.00	17.33	211.43	156.37	18.87	21.30	76.67	49.97	S	HS
N 27	34.67	23.33	204.20	165.87	19.00	19.60	76.67	47.80	R	MS
RB 94-2291	24.67	13.33	185.00	137.10	21.70	19.20	71.67	25.57	MS	HS
NCS-005	20.67	13.33	199.67	139.10	17.43	19.03	52.23	34.43	HS	HS
SP71-618	24.67	27.00	190.57	143.00	20.67	19.80	66.67	40.00	R	S
RB 86-3129	32.33	14.67	236.67	152.10	18.70	21.50	80.00	48.90	MS	HS
NCS-006	21.67	22.67	233.33	153.57	15.67	17.13	80.00	48.90	HS	HS
NCS-009	37.67	46.00	230.30	186.10	18.80	21.23	112.80	62.23	R	MS
CP 72-2086-1	27.33	14.67	156.33	109.00	23.00	23.70	87.77	31.10	S	S
B 93220	22.67	8.67	195.87	138.57	20.77	22.57	46.30	34.47	HS	HS
RB 86-7512	23.67	14.00	187.00	154.10	18.67	22.10	63.33	37.80	S	HS

BR 971007	26.33	20.33	179.67	137.97	21.63	23.87	66.67	33.37	HR	MS
BBZ 921101	17.67	14.67	196.33	153.20	18.43	22.63	50.47	31.13	MS	HS
B 47419	21.33	21.67	191.67	118.10	15.67	20.03	88.33	37.77	HR	MS
NCS 008	23.33	26.67	201.67	171.43	18.30	21.53	85.57	46.67	R	MS
RB 82-5211	17.00	19.33	178.90	148.97	18.17	20.63	64.43	38.90	MS	MS
O535	21.33	21.67	209.43	170.57	18.43	21.50	54.00	36.67	S	HS
BBZ 92653	28.67	25.67	205.67	147.33	18.63	22.03	82.67	45.57	MS	HS
B 245/B 0197	37.33	34.67	210.33	186.00	17.67	22.23	78.87	62.20	R	HS
CV %	30.1	30.3	13.2	12.7	7.6	5.0	37.2	34.7		
SE ±	4.56	3.66	14.72	10.81	0.83	0.60	14.40	8.55		

Note: PC= plant crop, RC = ratooned crop, STLK LNT= stalk length

Table 3 exhibits the incidence, rating and reaction types of the studied accessions to smut inoculation. The resistance to smut disease caused by *S. scitamineum* and subsequent whip smut development greatly varied among sugarcane accessions at different region. NCS-002, NCS-007, KNB9218, NCS-003, DB75159, BR971007 and B 245/B0197 proved to be highly resistant to smut infestation during the plant crop and eight accessions (B9054, B51410, B-2, N27, SP71-618, NCS-009, NCS-008 and B 245/B0197) were rated as resistant in their reaction to smut disease.

Smut disease incidence result of the ratooned sugarcanes accessions reveals that only NCS-002 was highly resistant to smut and NCS-007, KNB9218, B51410, NCS-003, DB75159, NCS-009 were also resistant, while all the remaining 28 accessions exhibit different susceptibility reaction type to the smut infestation.

The result of this study confirms the report of Hossain *et al.* (2020) that many genotypes showed different reactions to smut infestation in two consecutive years. They further said that it may be due to environmental variations and change of races/strains/pathotypes in two years. The researchers were of the opinion that sudden breakdown of the previous resistance accessions to smut disease is a pointer to the possibility of the existence of more virulent races of *S. scitaminea* than what was obtained before.

According to Croft and Braithwaite, (2006) ratooning can induce symptom development in latently infected plants. Marchelo *et al.*, (2008) had also reported the building up of smut in successive ratoons of cane especially in susceptible varieties. Sundar *et al.* (2015) stated that the breakdown of disease resistance is attributed to the possible emergence of new virulent pathotypes.

The variation to smut resistance among the studied accession agrees with the report of Agboire *et al*., 2002 and Sabalpara *et al*., 2002 and they demonstrated that source of resistance against smut exist among sugarcane genotypes and can be manipulated through breeding to evolve new promising sugarcane varieties.

CONCLUSION

Based on the result of this evaluation it is concluded that the studied accessions exhibit different reaction to smut infestation depending on the crop cycle. Variations in response to smut infestation revealed by the studied accessions suggested that the accessions differs in their genetic make up, thus providing good chances for sugarcane improvement.

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SMUT DISEASE MANAGEMENT STRATEGIES FOR SUSTAINABLE SUGAR CANE PRODUCTION

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ABSTRACT
Disease management strategies for sustainable sugar cane production were investigated by using two sugar cane genotypes [Bida local and commercial NCS 001], four rates of sugar cane trash mulch rates (0, 3, 6, 9 t ha^{-1}) and four weed management practices [weedy check, monthly hoe weeding for five months (5 MHW), application of PE diuron + POE 3 – maize force, and application of PE diuron plus POE 3 – maize force + 2 MHW] at Badeggi (Lat. 9° 45′ N, Long. 06° 07′ E). The treatments were arranged in a split-plot design and replicated three times in 2016 and 2017 cropping seasons. Results showed that application of 6 t ha^{-1} mulch produced comparable but lower whip smut incidence to 9 t ha^{-1}. Application of PE diuron plus POE 3 – maize force and 5 MHW, resulted in a comparable whip smut incidence to PE diuron plus POE 3 – maize force plus 2 MHW. Similarly, PE diuron plus POE 3 – maize force, 5 MHW and PE diuron plus POE 3 – maize force plus 2 MHW produced comparable brix content, number of stools and millable stalks. Application of PE diuron plus POE 3 – maize force proved equally effective as 5 MHW in contributing the highest cane yield. Lower whip smut incidence and cane yield were recorded in NCS 001. In all, application of 9 t ha^{-1} trash mulch with 5 MHW or PE diuron plus POE 3 – maize force plus 2 MHW or PE diuron plus POE 3 – maize force strategies effectively managed smut incidence in the present study. The strategies also increased cane girth, brix content, number of stool, millable stalks and cane yield of genotype NCS 001.
Keywords: *Bida local chewing cane, genotype NCS 001, whip smut incidence, trash mulch, cane yield.*

INTRODUCTION
Sugar cane (*Saccharum officinarum*) family Gramineae (Poaceae) is a widely grown crop in Nigeria. It provides employment to over a million people directly or indirectly besides contributing significantly to the national exchequer (FAOSTAT, 2019). Reduction in yield components and cane yield losses due to whip smut disease has been reported by Wada and Anaso (2016). Besides, in this agroecology in Nigeria, the common sugar cane types under production are the chewing cane for human consumption and commercial cane as raw materials for the sugar and sugar-related industries. One potential way to reduce the negative effects of weeds and diseases in the production of these sugar cane genotypes is to use large amount of the trash usually produced by sugar cane as mulch. Sugar cane trash mulches have a direct or an indirect mechanism to lessen disease incidence. This mechanism was also elaborated by Downer *et al.* (2002) who discovered the root rot disease through short- and long-term mulching effects. Other ways to improve the yield of sugar cane, irrespective of the genotypes is by weed management practices. Abiloye *et al*. (2018) and Bassey *et al*. (2021) reported that, PE diuron and POE 3-maize force application significantly reduced weed biomass by a slow rate of decomposition, which is related to its high concentrations of organic carbon, soil moisture content and reduced rate of evapotranspiration resulting from changes in the C/N ratio and allelopathy which translates to reduce the chances of whip smut disease incidence. Research information on disease management for sugar cane when sown under different rates of sugar cane trash mulch, weed management practices and whip smut incidence is scarce in Nigeria. Hence, the objectives of this study were to evaluate the effects of varying sugar cane trash mulch and application of weed management practices on disease management for sustainable sugar cane production.

MATERIALS AND METHODS
A field trial was conducted at the upland sugar cane experimental field of the National Cereals Research Institute, Badeggi (Lat. 9° 45′ N, Long. 06° 07′ E) in the southern Guinea Savanna agroecological zone of Nigeria in 2016 and 2017. Before cultivation, the vegetative cover of the experimental site was manually cleared, ploughed and harrowed with a tractor in the first week of February 2016 and 2017. The land was fully irrigated before planting

by pumping water from a stream using a 3.5 HP water pump with a 12.5 cm diameter hose. Thereafter, the land was marked out into plots with bunds at the edges for water retention. Gross plot size was 5 m x 4 m (20 m^2) consisting of 4 sugar cane rows, and net plot size was 5 m x 2 m (10 m^2) consisting of 2 sugar cane rows. Each row was spaced at 1 m apart. Tender healthy young stalks of seven months old of the two sugar cane genotypes were used as planting material. The stalks were cut into setts each containing three eye buds, planted continuously end-to-end without intra-row spacing in shallow sunken furrows which were later earthened up at 3MAP. The application of pre-emergence (PE) diuron was done immediately after planting at 2.0 kg a.i ha^{-1}. The application of post-emergence (POE) 3 – maize force [metolachlor 375 g L^{-1} plus terbuthylazine 125 g L^{-1} plus mesotrione 37.5 g L^{-1}] at 179.2 g ha^{-1} was applied at 5 weeks after planting (WAP). The NPK fertilizer was applied at 150 kg N, 60 Kg P_2O_5 and 90 Kg K_2O in equal halves at planting and 10 WAP. Irrigation water was applied at 41.3 L per plot once per week from February to April. Rainfall was supplemented with irrigation in May which marked the establishment of the rainy season.

The treatments consisted of a factorial combination of two sugar cane genotypes of chewing cane (Bida local) and commercial cane (NCS 001), and four weed management practices viz [weedy check, monthly hoe weeding for five months (5 MHW), application of PE diuron + POE 3 – maize force, and application of PE diuron plus POE 3 – maize force + 2 MHW] arranged in a split-plot design and replicated three times. Weed management practices were allocated to the main plot, while the two sugar cane genotypes were the subplot. Herbicides were applied with knapsack (CP3) sprayer at a spray volume of 4 L ha^{-1} at 206 KPa. Percent brix at harvest at 12 MAP was taken using Hand refractometer to determine the level of field sucrose. Sugar cane stools per plot were taken by counting the number of stools at 12 MAP with the aid of a tally counter. Millable stalks per stool were taken by counting the number of stalks at 12 MAP also with the aid of a tally counter. Cane yield at harvest was taken from the harvested stalks, weighed and expressed in t ha^{-1}.

Whip smut was not induced artificially in the test cane genotypes as the trial site has been repeatedly cropped to known susceptible canes to *Sporisorium scitamineum*, (Wada *et al*., 2016), so were left to natural infection. Percent smutted stools and stalks were calculated by first counting the total number of stools and stalks in a plot using a tally counter. Then the number of smutted stools and stalks in the same plot was counted and expressed as a percentage of the total to determine the incidence of whip smut at 3, 6, 9 and 12 MAP. All data collected were subjected to analysis of variance (ANOVA). The means were separated using Least Significant Difference (LSD) at 5 % level of probability using SAS version 9.2 statistical package (SAS, 2002).

RESULTS AND DISCUSSION

Smut incidence was significantly higher in Bida local cane than NCS 001 at 3 and 6 MAP in both years (Table 1). However, under trash mulch, smut incidence was highest in plot without mulching. Furthermore, weedy check recorded higher smut incidence compared to other sugar cane plot given the other weed management practices (Table 1). The relatively low smut incidence observed in NCS 001 may be attributed to heavy residue production and better weed competitive ability which stimulate the release of chemicals for the inhibition of pathogens thus, reducing the chances of smut disease spread as reported by Chalker-Scott (2007). On the other hand, the high whip smut incidence recorded in sugar cane plots without mulching agree with reports by other workers that dry environments favour whip smut invasion (Comstock, 2014; Wada *et al*., 2016). The relatively low smut incidence observed under weed management practices can be attributed to decrease in weed dry matter caused by weakening of stems and roots, depletion of weed seed bank and better conditions for crop growth, hence good cane yield. This is consistent with the findings of Singh *et al*. (2011) and Choudhary and Singh (2016).

Higher brix content was obtained in NCS 001 sugar cane compared with that from Bida local sugar cane in both years of study (Table 1). Furthermore, the highest brix content was found in sugar cane plants given 6 t ha^{-1}, but similar to that in 9 t ha^{-1} treated plots in both years. Also, 5 MHW and application of PE diuron + POE 3 – maize force herbicides in the two years of study, and PE diuron + POE 3 – maize force herbicides + 2 MHW in 2016 only recorded similar higher brix content compared to other sugar cane plants given the other weed management practices (Table 1). There was significant interaction between trash mulch and weed management practice on brix content of sugar cane in 2017 where under 5 MHW, brix content was not significantly increased as mulch was increased from 0 to 9 t ha^{-1} (Table 1). Application of 9 t ha^{-1} mulch in combination with 5 MHW, PE diuron + POE 3 – maize force herbicides + 2 MHW or PE diuron + POE 3 – maize force herbicides recorded the highest brix content in this study. Number of stools per plot varied significantly with weed management practices. Genotype NCS 001 produced more stools than Bida local in both years of study (Table 1). The highest number of stools was

Table 1: Effects of sugarcane trash mulch and weed management practices on Smut incidence and yield attributes of sugarcane genotypes in 2016 and 2017 seasons

Treatment	% Smut incidence 3 MAP		% Smut incidence 6 MAP		Brix content (%)		Number of Stools per plot		Millable stalks per stool		Cane yield (t ha^{-1})	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Genotypes (S)												
Bida local	2.5	6.0	3.0	3.1	16.49	16.74	9.17	17.63	3.01	3.29	52.12	57.24
NCS 001	1.7	2.8	2.5	2.9	18.28	18.29	11.75	22.17	5.51	5.33	82.27	66.18
LSD (0.05)	0.2	1.1	0.3	0.4	0.62	0.58	1.27	1.47	0.52	0.40	4.63	4.61
Mulch rate (tha^{-1})												
0	2.7	13.5	3.2	3.1	16.89	16.36	7.75	16.88	3.39	3.21	52.36	41.47
3	2.1	7.5	2.8	3.0	16.28	16.60	10.33	21.33	4.06	4.04	68.71	67.13
6	1.4	8.5	2.8	3.0	17.82	18.14	10.66	19.54	4.54	4.67	70.95	67.99
9	2.1	9.2	2.2	2.8	18.63	18.95	13.08	21.83	5.05	5.33	76.74	70.24
LSD (0.05)	0.2	1.5	0.4	0.6	0.31	0.49	1.79	2.09	0.73	0.57	2.82	2.55
Weed management (W)												
Weedy check	2.3	9.9	3.0	4.4	16.60	16.30	8.17	14.67	3.63	3.75	57.33	54.91
5 MHW	1.8	8.7	2.9	4.0	18.15	18.38	11.79	20.83	4.63	4.63	77.54	61.29
PE +POE + 2 HW	2.0	9.6	2.7	2.5	17.11	17.38	10.46	21.88	4.35	4.29	66.08	63.76
PE +POE	2.3	9.4	2.4	0.9	17.68	18.0	11.42	22.21	4.43	4.58	67.81	66.87
LSD (0.05)	0.2	1.6	0.3	0.6	1.29	0.82	1.79	2.09	0.73	0.57	8.36	5.23

LSD - least significant difference, MHW-Monthly hoe weeding, PE- Pre-emergence (Diuron at 2 kg a.i/ha) herbicide, POE-Post-Emergence (3-Maize force at 179.2 g/ha) herbicide, NS-Not significant

Found in sugar cane plots given 9 t ha^{-1} in both years. The 5 MHW and application of PE diuron + POE 3 – maize force herbicides in the two years of study, recorded similar higher number of stools compared to sugar cane plots given the other weed management practices (Table 1). The production of consistently taller sugar cane stalk, higher brix and cane yield in plots with NCS 001 can be attributed to better crop growth in terms of internode length and tillering ability governed by its superior genetic potential and efficient use of applied inputs for improved growth and cane yield. The present result agrees with the findings of Kuri and Chandrashekar (2015).

Genotype NCS 001 significantly produced more number of millable stalks than Bida local (Table 1). Sugar cane applied with 9 t ha^{-1} mulch recorded significantly higher millable stalks than the lower rates in each year of the study (Table 1). Weed management practices significantly affected number of millable stalks per stools Application of 5 MHW produced more millable stalks in 2016 and 2017 seasons, which were similar to those of other weed management treatments. The weedy check consistently produced the lowest millable stalks throughout the study period. The observed increase in the number of stools and millable canes might also be attributed to decrease in weed infestation, increased soil organic matter, improved physical and chemical properties and soil water regimes, which translates into better crop growth. This is in agreement with the work of Cheong and Teeluck (2015)

Cane yield was significantly higher in NCS 001 plots compared with Bida local in the two years of study (Table 1). Furthermore, application of 9 t ha^{-1} mulch recorded significantly higher cane yield compared to plots applied with lower rates in both years. Application of 5 MHW produced higher cane yield in 2016 plant crop while cane yield of PE +POE and PE + POE + 2 MHW were at par. On the other hand, application of PE +POE herbicide recorded the highest cane yield but was at par with PE + POE + 2 MHW treatments in 2017. The result of higher cane yield in this study was similar to the work of Mohammed *et al*. (2019) who recorded the highest cane yield with ILS 708-05 genotype compared to other genotypes tested. These authors also stated that high brix content and cane yield by a sugarcane genotype is a function of the higher genetic potential of the variety.

CONCLUSION

This study has shown that the application of 9 t ha^{-1} trash mulch with 5 MHW or PE diuron plus POE 3 – maize force plus 2 MHW or PE diuron plus POE 3 – maize force effectively managed whip smut incidence, increased growth and cane yield of sugar cane, especially NCS 001 in this agroecology of Nigeria.

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FIRST REPORT OF *APANTELES* SPP. (HYMENOPTERA: BRACONIDAE) FROM *TUTA ABSOLUTA* (LEPIDOPTERA: GELECHIIDAE) INFESTING TOMATO IN NIGERIA.

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ABSTRACT
The incidence of a devastating invasive pest of South American origin, the tomato leafminer, Tuta absoluta (Meyrick) (Lepidoptera: Gelechiidae), on tomato (Solanum lycopersicum L.), was reported for the first time in Abeokuta, Ogun State, Nigeria in 2015. The outbreak of this pest in Nigeria and its devastating effects on tomato makes research on its developmental stages as well as search for parasitoids associated with the pest that could be used as potential biological control agent for the management of Tuta absoluta in Nigeria. Samples of T. absoluta used for this study were obtained from infested tomato leaves containing eggs and neonate larvae of the pest at the tomato green houses of Ogun State Agricultural Development Programme (OGADEP), Kotopo, Abeokuta, Ogun State, Nigeria. Eggs and neonate larvae from infested leaves were reared in the Entomology laboratory Horticultural Research Institute, Ibadan Nigerian, at room temperature (25°C - 30°C), relative humidity of 79 – 92% and a 12 hours photoperiod until adult moth and parasitoid emerged. A mean total developmental period of 18.77 days was recorded. A parasitoid species was identified as Apanteles spp and (Hymenoptera: Braconidae) is now reported for the first time on Tuta absoluta in Nigeria. This information is important because the parasitoid being a biocontrol agent, can form an important component in the development of an integrated pest management(IPM) programme for the management of the pest in Nigeria.
Keywords: *Tuta absoluta, Apanteles spp, Lycopersicon esculentum*

INTRODUCTION
The tomato leafminer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae), is a key pest of tomato, *Lycopersicon esculentum* L. in Central and South America regions, from where it is allegedly native (Vargas, 1970; Fernandez and Montagne, 1990; Ulle and Nakano, 1994; Uchoa-Fernandes *et al*., 1995; Colomo *et al*., 2002). The larvae of *T. absoluta* attack leaves, stems, and fruits of tomato plants resulting to a yield loss of between 80 - 100% (Lopez, 1991). *Tuta absoluta* (Meyrick) was accidentally introduced to Spain in 2006, from where it spread north to the Netherlands and east to Iran (Desneux *et al*., 2010; 2011; Baniameri and Cheraghian, 2012). In northern Africa, it was reported in Tunisia in 2008 (Abbes *et al*., 2012), Morroco in 2008 (Ouardi *et al*., 2012), north of the Sahel in 2008 (Desneux *et al*., 2011), Sudan and Ethiopia in 2011 (Anon. 2012), Senegal 2013(Pfeiffer *et al*., 2013).
It was detected in Kano State, the largest tomato producing State in Northern Nigeria in early 2015 and by September 2015, unusual larvae feeding symptoms were observed on tomato in the greenhouses of Ogun State Agricultural Development Programme (OGADEP), Kotopo, Abeokuta Ogun State, Nigeria. The invasion of *Tuta absoluta* into Nigeria in 2015 wiped away tomato production in Northern Nigeria and subsequently delayed the take-off of Dangote tomato processing industry which was slated to start production in 2015 . Damage to tomato was caused by the larvae found feeding on leaves, stems and fruits of the plants. On leaves, the larvae fed on the mesophyll tissue within the leaf epidermis, forming irregular leaf mines which later became necrotic, reducing the photosynthetic ability of the plants. On stems, larvae formed extensive galleries which affected the physiological functions of the plants. Fruits were also attacked by the larvae predisposing them to secondary pathogens, leading to fruit rot (Mahlangu *et al*., 2022).
Insecticide application was the main management method adopted by farmers to control *T. absoluta* which was however not quite effective due to the endophytic behaviour of larvae and the development of pesticides resistance by field populations of the pest (Lietti *et al.*, 2005). There are however, potentials for the effective management

of the pest through the use of indigenous parasitoids of the pests (Zappalà *et al*., 2013; Biondi *et al*., 2013; Ferracini *et al*., 2012; Zappalà *et al*., 2012; Urbaneja *et al*., 2012; Abbes *et al*., 2013). Identification of *Apanteles* spp. as a parasitoid of the pest in Nigeria calls for intense study on the biology of the pest and the possibility of rearing the parasitoids for use as biocontrol agents in the management of *T absoluta* in Nigeria.

MATERIALS AND METHODS

Detection of *Tuta absoluta* infestation in the commercial greenhouses (24 × 8 m with 0.3mm size mesh of 45 cm width on the 2 lengths of each greenhouse) of Ogun State Agricultural Development Programme (OGADEP), Kotopo, Abeokuta Ogun State, Nigeria in September 2015. Leaf samples containing 32 eggs and 146 first instar larvae were randomly collected from tomato plants and placed in paper bags. The samples were transferred to the Entomology laboratory of National Horticultural Research Institute, Ibadan Nigerian and reared at room temperature (30°C - 34°C) and relative humidity of 79 – 92% and a 12 hours photoperiod. All the samples collected (leaves with 32 eggs and infested leaves with 146 first instar larvae) were kept in a dual purpose Kilner jar lined with moist filter paper and covered with mesh for aeration and arranged on a work bench. Fresh tomato leaves were introduced into the jars from time to time to ensure the availability of fresh food until pupation.

The above procedure was repeated in the same year with 8 leaves containing 57 eggs and other tomato leaves containing 205 first instar larvae. Emerged moths and their parasitoids were killed with cotton wool soaked in ethyl acetate in a dual purpose Kilner jar. Specimens were mounted and dried in an oven at 35°C for 24 hours and stored in insect boxes and later identified at the insect museums of Department of Crop Protection and Environmental Biology, University of Ibadan, Nigeria.

Parameters Assessed and Statistical Analysis

Parasitoids that emerged were identified and counted while the mean values in days of the developmental stages of *T. absoluta* from egg to adult stage were observed and recorded. Descriptive statistics was used to analyze the data obtained.

RESULTS

Table 1: Developmental period of *Tuta absoluta* and the number of emerged parasitoid at 30°C - 34°C and 79–92% R.H in September

Developmental stage	Mean developmental period (day)	Total number	DevptlRange (day)	Number of emerged parasitoid
Egg to first instar	2.1	32	1-3	0
last instar larvae		146		
Pupae	10.0	57	7-11	0
Pupation to adult emergence	5.7	38	5-7	1 (2.44%)*
Total	17.8			

*Percentage of emerged parasitoid from 41 pupae

Table 2: Developmental period of *Tuta absoluta* and the number of emerged parasitoid at 30°C - 34°C and 79–92% R.H in October, 2015

Developmental stage	Mean developmental period (day)	Total number	Range (day)	Number of emerged parasitoid
Egg to first instar	2.7	59	1-3	0
Last instar larvae to		205		
Pupation	11.6	138	7-12	0
Pupation to adult emergence	6.2	84	4-7	2 (2.33%)*
Total	20.5			

*Percentage of emerged parasitoid from 86 pupae

The mean total developmental period in September 2015 from egg to adult emergence was 17.8 days as shown in Table1. The eggs collected on tomato leaves from the green house fields hatched to first instar larvae within 1 – 3 days (2.1 days mean). Only 57 out of the 146 first instar larvae collected from infested tomato leaves pupated between 7 – 11 days (10.0 days mean). Subsequently, 38 adults of *Tuta absoluta* emerged from the pupae within 5 – 7 days (5.7 days mean). One parasitoid species was identified as *Apanteles* spp. (Hymenoptera:Braconidae) and is now reported for the first time to the best of my knowledge as a parasitoid of T. absoluta in Nigeria.

Similarly, in October 2015, the mean total developmental period from egg to adult emergence was 20.5 days. The 12 eggs collected on tomato leaves from the green house fields hatched to first instar larvae within 1 – 3 days (2.7 days mean). From the 205 first instar larvae collected, only 138 pupated between 7 – 12 days (11.6 days mean). Subsequently, 84 adults *Tuta absoluta* moth emerged from the pupae within 4 – 7 days (6.2 days mean). The same parasitoid (*Apanteles* spp.) was observed on the larvae of *T. absoluta*.

DISCUSSION

The developmental of *Tuta absoluta* from egg to adultgreatly depends on environmental conditions, with average development time of 23.8 days at 27.1ºC (Barrientos *et al*., 1998). The mean developmental period from egg to adult of *T. absoluta* was reported to be 30.18 days at 25 - 26° C and 60 - 70% R.H. (Erdogan and Babaroglu, 2014) while Cuthbertson (2011) reported that the development from egg to adult took 35 days at 25ºC. However, the findings of this research with mean developmental period of between 17.8 – 20.5 days at 30 – 34 ºC would have concurred with the reports of the authors above if the incubation periods of eggs in the green houses were properly recorded in addition to the higher temperature conditions under which the research was conducted.

Classical biological control programmes of several exotic pests species demonstrated the importance of indigenous natural control agents in the regulation of pest populations (Simberloff and Stiling 1996; Pimentel, 2000). In Colombia, Oatman and Platner (1989) reported a broad complex of parasitoids such as *Apanteles* spp. (Hymenoptera: Braconidae) a larval and pupal parasitoid, *Apanteles dingus* (Hymenoptera: Braconidae) a larval parasitoid and *Apanteles gelechiidivoris* (Hymenoptera: Braconidae) had received particular attention in the management of pests species (Vallejo, 1999). The ability of *Apanteles* spp (2.44% and 2.33%) observed parasitizing the larvae of *Tuta absoluta* indicates its potential as an indigenous biological control agent of *Tuta absoluta* in the country. Further studies on rearing, multiplication and used of *Apanteles* spp. is suggested for inclusion in the development of biological control program to manage *T. absoluta.*

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INFLUENCE OF FERTIGATION ON *TUTA ABSOLUTA* INFESTATION AND TOMATO YIELD ON THE FIELD

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ABSTRACT
The South America tomato pinworm Tuta absoluta (Meyrick) (Lepidoptera: Gelechiidae) is currently the worst pest of tomato in Nigeria due to its high infestation levels and damage to tomato. Integrated pest management (IPM) strategies are quintessential to control T. absoluta. However, the current IPM strategies for the pest in Nigeria is elementary, and insecticides are the primary control tools, butare however not quite effective in the management of the pest and hence, the unrelenting high yield losses of tomato in the country. The effects of three levels of nitrogen (low, normal and high), three irrigation regimes (once per week, twice per week and once in 10 days) and four management measures (NIHORT-Tuta trap tray, NIHORT-Lyptol, NIHORT-Raktin, and spirotetramat 75g/ L + flubendiamide 100g/ L) are evaluated on the population of T. absoluta and tomato yield. At one application per 10 days (drought) + varying levels of nitrogen with application of managements, there were no record of T. absoluta population and yield loss in the field however, at one application per week +varying levels of nitrogen and management measures, Tuta populations, marketable fruit weight, unmarketable fruit weight, average fruit weight and fruits Yield were recorded and found to be significantly (P<0.05) less than those observed at two applications per week with varying levels of nitrogen and application of control measures. The highest fruit yield was obtained when Tuta populations were low at two applications per week with normal nitrogen and biorational control management compared to synthetic insecticides.
Keywords: *NIHORT-Lyptol, NIHORT-Raktin, Tuta absoluta, Tomato*

INTRODUCTION
The South American tomato pinworm *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) is an invasive pest of tomatoes in Nigeria (Sanda *et al*., 2018). Following its first detection in Nigeria in 2015, the impacts of *T. absoluta* on tomato production in the country has been serious, causing 100 % yield losses, if left untreated (Oke *et al.*, 2017a, Bala *et al*., 2019). The current economic losses in tomatoes associated with *T. absoluta* in one growing season in Nigeria is estimated at six million US dollars (Bala *et al*. 2019; Sanda *et al*., 2018; Oke *et al*., 2017b). Like most Lepidopteran pests, its four larval instars are the damaging life stage. These caterpillars penetrate, mine, feed, and develop in tomato leaf tissues, consequently limiting and disrupting photosynthesis in tomatoes (Desneux *et al*., 2010; Mansour *et al*., 2018). *Tuta absoluta* is difficult to control and most open-field tomato growers rely on the use of insecticides, which has led to the pest developing resistance to insecticides even in South America and across Europe (Guedes *et al*., 2019). Since the invasion of this pest in Nigeria in 2015, the National Horticultural Research Institute (NIHORT), Nigeria, has developed some Integrated Pest Management (IPM) methods that are environmentally friendly, effective, sustainable, and simple to use. These methods include an insect Trap Tray Technology (TTT), which can be used as attract and kill device. This device attracts and kills *T. absoluta*, and several thousand adults can be killed using a single TTT (Oke *et al*., 2017). Other control strategies such as biopesticides from botanical products (NIHORT-Raktin and NIHORT-Lyptol) have also been developed and patented for the control of *T. absoluta* in Nigeria. However, to develop a complete and an effective IPM strategy, the integration of several control methods is paramount (Desneux *et al*., 2022). This necessitates research into exploring cultural practices by farmers for pest control as well as biotic factors and abiotic factors

such as natural enemies, the role of climatic factors, and fertilization and water inputs, which are important factors that regulate the population of insects.

Bottom-up effects of fertilization and irrigation are crucial for *T. absoluta* population growth (Han *et al*., 2019). The literature on plant–insect interactions has long been central to understanding insect and plant community structure and dynamics (Bruce, 2015). Variability in plant nutritional components is determined by factors such as water, nutrient availability, and others (Gutbrodt *et al.,* 2011; Inbar *et al*., 2001). Such variations in plant quality can lead to trophic cascades such as bottom-up effects on phytophagous arthropods (e.g., on development, fecundity, etc.) (Hunter, 2001). Nitrogen is one of the most applied mineral fertilizers in crop production due to its importance in the composition of plant tissues. The development of Lepidopterans has been positively or negatively correlated to plant nitrogen content, also plant water content is a useful index of its nutritional value for many Lepidopterous larvae (Schoonhoven *et al*., 2005; Inbar *et al.*, 2001). In addition, drought may influence plant chemical defense levels, leading to either enhanced or reduced resistance to herbivores (Inbar *et al*., 2001). Historically, drought periods have been considered a major factor underlying outbreaks of herbivorous insects (White, 1969; Mattson and Haack, 1987). Manipulation of fertilizer levels and irrigating regimes may help to optimize agricultural practices by promoting negative effects on herbivorous insects. However, little damage to plants and negligible crop yield losses may be required (Chau, 2005; Chow, 2012). To minimize *Tuta* damage and increase tomato yield, most smallholder farmers in Nigeria have resorted to increase in fertilizer application with concomitant decrease in irrigation regimes. However, infestation levels and economic damage induced by *T. absoluta* are not abating but rather worsening. Therefore, this paper is focused to investigate the role of fertigation in tomato yield and *T. absoluta* infestation in Nigeria.

MATERIALS AND METHODS

Experimental site and layout

The experiment was carried out in Danja, Katsina State using UC82B Tomato variety.

Experimental design

Tomato seedlings were raised on nursery seed beds and covered with a thin layer of rice straw mulch in January 2022. At two-leaf stage, seedlings were irrigated once with 2.5 g NPK 15-15-15 dissolved in 1 liter of water. At 4 weeks, seedlings were transplanted at planting space of 50 cm and 35 cm intra and inter row respectively. It was a factorial experiment laid in a Randomized Complete Block Design (RCBD) with three replications. A total of 28 plants were planted per replicate per plot. Each experimental plot was 2.1 x 2 m (4.2 m^2). The plants were exposed to the natural field infestation by indigenous population of tomato leaf miner.

Treatment applications

Fertilizer levels

A. Low Nitrogen (LN): NPK 15:15:15 (150 kg/ha) was used as a basal dose in two splits (at two and at five weeks after transplanting (WAT) while Urea fertilizer (50 kg/ ha) was added at seven weeks after transplanting (first fruit-set).

B. Normal Nitrogen (NN): NPK 15:15:15 (300 kg/ha) was used as a basal dose in two splits (at two and at five weeks after transplanting (WAT) while Urea fertilizer (75 kg/ ha) was added at seven weeks after transplanting (first fruit-set).

C. High Nitrogen (HN NPK 15:15:15 (600 kg/ha) was used as a basal dose in two splits (at two and at five weeks after transplanting (WAT) while Urea fertilizer (100 kg/ ha) was added at seven weeks after transplanting (first fruit-set).

Irrigation regimes

i. Drenching of the field once in a week
ii. Drenching of the field twice in a week
iii. Drenching of the field once in 10 days

Management practices

Hand weeding was done three times using hoe at 3, 6 and 9 weeks after transplanting (WAT).

Biorational Tuta management:

1. NIHORT-Tuta trap tray set at 288 m^2, bio-pesticides: NIHORT-Lyptol
2. NIHORT-Raktin sprayed rotationally at 2, 4, 6 and 8 weeks at 1 litre/ 5 litres water.
3. Synthetic insecticide: spirotetramat 75g/ L + flubendiamide 100g/ L sprayed at 15ml/ 15 litres water once in week from week 2 to week 9 (8 times) according to farmers practice.

Data Collection

Data were collected on five randomly selected plants in each plot at one, three, six and nine weeks after transplanting. Upper 3 leaves were selected from each of the five plants and the percentage leaf damage by *T. absoluta* was recorded. Weight of Marketable fruits (kg) (unblemished fruits ≥15g), non-marketable fruits (kg) (blemished fruits and/ or ≤ 15g), and yield per hectare (ton); were measured using digital weighing scale.

Data analysis

Analysis of variance was performed using the general linear model (GLM) procedure in the SAS software and means were compared using Duncan's multiple Range test.

RESULTS

There was no record of *T. absoluta* infestation from untreated plots within the 9 weeks of observations in Fertigation at one application per 10 days + varying levels of nitrogen, however, Tuta infestation gradually increased with increase in applications per week from once per week + varying levels of nitrogen to twice per week + varying levels of nitrogen until complete infestation of the plants was observed at the 9th week with 6 treatments: once / week + low nitrogen, once / week + normal nitrogen, once / week + high nitrogen, twice/ week+ low nitrogen, twice/ week+ normal nitrogen, and twice/ week+ low nitrogen. No Marketable fruit weight was recorded on any of the treatment interactions while unmarketable fruit weight, and fruits yield were significantly affected by fertigation and irrigation interaction. The highest unmarketable fruit weight which translated to fruits yield (0.3kg) and highest average fruit weight (12.16g) were recorded with twice per week + normal nitrogen interaction. Once per 10 days + varying levels of nitrogen interactions did not produce flowers and so no fruits set (Table 1).

Table 1: Effect of Fertilization and Irrigation Regimes on *Tuta Absoluta* Infestation, Marketable Fruit Weight, Unmarketable Fruit Weight, Average Fruit Weight and Fruit Yield/ Hectare (Ton/ Ha) Of Tomato Without Control Between January – May 2022

Fertigation regime	Nitrogen levels	*Tuta absoluta* populations				MFW	UmFW	AFW	FY
		1WAT	3WAT	6WAT	9WAT	(kg)	(kg)	(g)	(t/ha)
Once/ week	LN	-	19.6a	97.9b	100b	0	0.08a	9.24a	0.08a
Once/ week	NN	-	23.7b	85.4b	100b	0	0.09a	9.24a	0.09a
Once/ week	HN	-	21.5b	100b	100b	0	0.13a	9.27a	0.13a
Twice/ week	LN	-	23.7b	100b	100b	0	0.21b	11.25b	0.21b
Twice/ week	NN	-	27.4c	100b	100b	0	0.37b	12.16b	0.37b
Twice/ week	HN	-	29.8c	100b	100b	0	0.30b	11.25b	0.30b
Once / 10 days	LN	-	0	0	0	*	*	*	*
Once / 10 days	NN	-	0	0	0	*	*	*	*
Once / 10 days	HN	-	0	0	0	*	*	*	*

Means followed by different letter (s) differ significantly at P≤ 0.05 using DMRT WAT= weeks after transplanting, MFW= marketable fruit weight, UmFW= unmarketable fruit weight, AFW= average fruit weight and FY= fruits Yield

In spirotetramat 75g/ L + flubendiamide 100g/ L sprayed field, Tuta populations were not recorded within the 9 weeks of observations however, at one fertigation per 10 days + varying levels of nitrogen Tuta populations showed a gradual increase with increase in number of applications per week from one application with varying levels of nitrogen to two applications per week + varying levels of nitrogen.
However, a complete devastation of the plants were not observed at the 9th week with the 9 treatments. The highest infestations within the 3,6 and 9 weeks were observed on twice per week + normal nitrogen regime (7.2, 47.5 and 51.3) respectively (Table 2). Marketable fruit weight was recorded on all the treatment interactions with twice per week + high nitrogen yielding the highest of 4.45kg although this yield was not significantly different from 4.26kg obtained from twice per week + normal nitrogen. The highest unmarketable fruit weight (2.25kg) was recorded on twice per week + low nitrogen while the highest average fruit weight (47.62g) was obtained from twice per week + high nitrogen regime, however, this value is not significantly different from those obtained on twice per day + normal nitrogen interaction (47.37g). Fruits yield were significantly affected by fertigation and irrigation interaction. Also, the highest fruit yield (6.42kg) was recorded with twice per week + high nitrogen interaction, similarly, this value is not significantly different from those obtained on twice per week + normal nitrogen interaction (6.34kg). Once per 10 days + varying levels of nitrogen interactions did not produce flowers and so no fruits *set al*so (Table 2).

Table 2: Effect of Fertilization and Irrigation Regimes on *t. absoluta* Populations, Marketable Fruit weight, Unmarketable Fruit weight, Average fruit weight and yield/ hectare (ton/ ha) of Tomato with spirotetramat 75g/ l + flubendiamide 100g/ l for control of *tuta absoluta* between January – May 2022

Fertilization regime	Irrigation regime	Tuta infestation				MFW (kg)	UmFW (kg)	AFW (g)	FY (t/ha)
		1WAT	3WAT	6WAT	9WAT				
Once/ week	LN	-	5.2b	18.9a	36.4b	2.84a	1.33a	30.28a	4.17a
Once/ week	NN	-	6.5c	36.3b	37.6b	3.65b	1.00a	31.83a	4.65a
Once/ week	HN	-	4.1a	20.6a	37.6b	3.71b	1.52b	35.11a	5.23b
Twice/ week	LN	-	5.0b	49.2c	45.5a	3.64b	2.25d	42.54b	5.89c
Twice/ week	NN	-	7.2d	47.5c	51.3a	4.26c	2.08c	47.37b	6.34d
Twice/ week	HN	-	6.7c	50.4c	43.7a	4.45c	1.97c	47.62b	6.42d
Once / 10 days	LN	-	0	0	0	*	*	*	*
Once / 10 days	NN	-	0	0	0	*	*	*	*
Once / 10 days	HN	-	0	0	0	*	*	*	*

Means followed by different letter (s) differ significantly at P≤ 0.05 using DMRT WAT= weeks after transplanting, MFW= marketable fruit weight, UmFW= unmarketable fruit weight, AFW= average fruit weight and FY= fruits Yield.

Results obtained using biorational treatments of NIHORT-Tuta trap tray, NIHORT-Lyptol and NIHORT-Raktin sprays on tomato fields showed that, Tuta populations were not recorded within the 9 weeks of observations at one application per 10 days + varying levels of nitrogen however, Tuta population records appeared to also gradually increased with increase in number of applications per week. The high number of Tuta populations recorded at two applications per week + low nitrogen, normal nitrogen and high nitrogen levels (32.3, 35.8 and 27.1) respectively were at par and did not differ among themselves. Marketable fruit weight had the highest record (7.04 kg) at two applications per week with normal nitrogen followed by 7.01kg obtained from two applications per week + high nitrogen though there was no significant difference between the two however the least at Two applications per per week + low (1.01kg). The highest average fruit weight (49.21g) and fruits yield were significantly affected by fertigation and irrigation interaction with the highest fruit yield (8.09kg) being recorded on twice per week + high nitrogen interaction, similarly, this value is not significantly different from those obtained on twice per week + normal nitrogen interaction (8.05kg). Once per 10 days + varying levels of nitrogen interactions did not produce flowers and so no fruits s*et al*so (Table 2).

Table 3: Effect of Fertilization and Irrigation Regimes on *T. absoluta* infestation, Marketable fruit weight, Unmarketable fruit weight, Average fruit weight and fruits yield/ hectare (ton/ ha) of tomato with biorational: Nihort-tuta trap tray, Nihort-lyptol and Nihort-raktin for control of *tuta absoluta* between January – May 2022.

Fertigation regime	Nitrogen levels	Tuta populations				MFW (kg)	UmFW (kg)	AFW (g)	FY (t/ha)
		1WAT	3WAT	6WAT	9WAT				
Once/ week	LN	-	4.3a	16.2a	15.6a	2.27a	2.51d	31.01a	4.78a
Once/ week	NN	-	4.6ab	16.6a	21.0b	2.90a	2.21c	32.28a	5.11b
Once/ week	HN	-	5.4c	15.8a	24.6b	4.26b	2.10c	32.83a	6.36c
Twice/ week	LN	-	5.2bc	20.7b	32.3c	5.98c	1.45b	40.15b	7.43d
Twice/ week	NN	-	5.0b	22.4b	35.8c	7.04d	1.01a	49.21c	8.05e
Twice/ week	HN	-	4.9b	22.1b	37.1c	7.01d	1.08a	49.17c	8.09e
Once / 10 days	LN	-	0	0	0	*	*	*	*
Once / 10 days	NN	-	0	0	0	*	*	*	*

Once / 10 days	HN	-	0	0	0	*	*	*	*

Means followed by different letter (s) differ significantly at P≤ 0.05 using DMRT, WAT= weeks after transplanting, MFW= marketable fruit weight, UmFW= unmarketable fruit weight, AFW= average fruit weight and FY= fruits Yield

DISCUSSION

The varying levels of nitrogen and irrigation regime significantly affected *T. absoluta* infestation on tomato plants consequently affecting plant yield. Drought resulting from minimal application of irrigation, regardless of the level of fertilizer application once per 10 days+ varying levels of nitrogen) resulted in plants with small leaf area and thick cuticle. This made the leaves unattractive and unappealing to *T. absoluta* for feeding and as oviposition site. Tuta populations infestation irrespective of application of pest control, triggers negative bottom-up effects on Tuta which was consistent with the ''Nitrogen limitation hypothesis'' (White, 1993). The level of drought resulted in the plants not reaching its maximum physiological stage of setting flowers and producing fruits. Also, no *T. absoluta* infestation was observed when irrigation was done once in 10 days implying that drought negatively affected *T. absoluta* survival and development. The foliage of the water stressed plant tended to wilt thus probably becoming less edible or nutritious for Lepidoptera larvae (Gutbrodt *et al*., 2011)· This suggests that larvae had difficulty in obtaining enough water for optimal development thus causing a slowdown in their development (Peng *et al*., 2014). In addition, water not only acted as an indispensable ingredient for herbivore metabolism but also mediated nitrogen availability for plants (Huberty and Denno 2004). It is generally known that nitrogen and water contents are positively correlated, to *T. absoluta* larvae development and therefore may suffer a deficit of N-based nutrient in the plants subjected to drought (Cardenas-Navarro *et al*., 1999).

When fields were irrigated once a week with a low Nitrogen level applied, (once per week + low nitrogen) there aws infestation of *Tuta absoluta* on tomato irrespective of the application of control measure and when compared to twice a week irrigation regime. Reduction in the survival rate from egg to pupa or adult stages, pupal weight and consequent slow-down of the development of *T. absoluta* can result from feeding on plants of low quality (Peng *et al*., 2014). These clearly shows that altered nitrogen and water inputs to tomato plants do trigger a bottom-up effect on the biological traits of *T*. absoluta. Peng *et al.* (2014) inferred that *T. absoluta* larvae could be affected by changes in nutritional value and chemical defense in tomato plants. Indeed, nitrogen was considered as a limiting nutrient factor for the growth of many Lepidopteran herbivores because larvae may experience lack of organic nitrogen, i.e. specific protein and/or amino acids, leading to reduced or impaired metabolism during their critical growth period and even to premature death (Hunter and McNeil 1997). Moreover, concentration of non-nitrogeneous compounds in leaves could also be negatively affected by insufficient nitrogen input, such as starch in tomato leaves as well as soluble carbohydrate in young tomato leaves (Royer *et al.*, 2013).

Furthermore, N-limited tomato plants could have higher levels of chemical defense against *T. absoluta*. GDBH (Growth Differentiation Balance Hypothesis) predicts that moderate growth limitations caused by external factors such as low nutrient availability will result in an accumulation of carbohydrates and, subsequently, in increased concentrations of constitutive secondary compounds (Herms and Mattson, 1992). The N-limited tomato plants produced more insect-defensive soluble phenolics (C-based defensive compounds) i.e. chlorogenic acid, rutin, kaempferol-rutinoside since their con- centration is positively correlated with C/N ratio in tomato leaves (Stout *et al.*, 1998). Moreover, the concentration of constitutive tomatine, a key N-based glycoalkaloid defensive compound in tomato, is also positively correlated with leaf C/N ratio (Royer *et al.*, (2013). The application of recommended nitrogen twice a week contributed significantly to increase in leaf area of tomato plant which leads to increase in yield of tomato to certain level. This had the implication on the record of the increased infestation of Tuta and yield of the plants across the control management applied. However, the application of biorational: NIHORT-Tuta trap tray, NIHORT-Lyptol and NIHORT-Raktin enhanced the lowest infestation of Tuta and consequent highest fruit yield reported. Therefore, in developing an integrated pest management for *T. absoluta* involving the use of NIHORT-Tuta trap tray, NIHORT-Lyptol and NIHORT-Raktin, cultural practices such as fertilizer application and level of irrigation regimes are vital as observed in this study.

CONCLUSION

In the field, nitrogen and water inputs to tomato plants affected the *T. absoluta* population on tomatoes and these effects were probably due to a combination of nutritional value and higher chemical defenses, supporting both the ''Plant vigor hypothesis'' and the ''Nitrogen limitation hypothesis'' which are well reported for Lepidoptera pests. Normal fertilization + twice per week irrigation regimes to tomato plants under the applied treatments increased, marketable fruit weight, average fruit weight and fruits yield, however, the highest values were recorded under biorational Tuta management. Irrigation is more critical for tomato growth and production of flowers which provides favourable condition for reproduction of *T. absoluta*. However, the application of biorational control management curb its devastation and consequent production of safe tomato fruits.

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AUTHOR CONTRIBUTIONS

A.O.O. scoped and designed the study; A.O.O., A.O., P.A.A. and A.O.A. performed the experiments and analyzed data; A.O.O.A, A.O., P.A.A. and A.O.A. interpreted results, wrote, and edited the manuscript.

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FIRST REPORT OF THE OCCURRENCE AND ABUNDANCE OF NATURAL ENEMIES OF THE SOUTH AMERICAN TOMATO PINWORM *TUTA ABSOLUTA* (MEYRICK) IN NIGERIA

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ABSTRACT
The invasion of the South American tomato pinworm, Tuta absoluta (Meyrick) (Lepidoptera: Gelechiidae) to Nigeria in 2016 is one of the most damaging to tomato production. Growers have largely relied on applying synthetic chemical insecticides as the primary management strategy, but excessive use is harmful to the humans and environment. Effect and sustainable control requires the development of IPM with a primary focus on biological control. This study investigated the occurrence, distribution, and abundance of natural enemies of T. absoluta in Nigeria. Sampling was done across four local government areas each from four major tomato-producing states in northern Nigeria. A total of 18 potential natural enemies of T. absoluta including ten predators and eight parasitoids in the Hemipteran and Hymynopteran insect orders were identified. Tapinoma nigerriumu was very abundant across most of the farms sampled in the four States. Similarly, Pheidole spp and N. tenuis were very abundant or moderately abundant, although occurring in few numbers or absent in some farms. Podisus nigrispinus and Zelus spp. were mostly abundant but D. errans, M. pygmaeus, B. pallescens, Xylocoris spp and Debilia spp were rarely or not found in each of the states sampled. This study concluded that the observed biological control agents can be explored for inundative or inoculative releases in the development of biological control programme for this pest.

Keywords: *Natural enemies, biocontrol agents, invasive pests, IPM.*

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INTRODUCTION
Nigeria is the largest producer of tomatoes in sub-Saharan Africa (SSA) (FAOSTAT, 2019), and tomato is one of the most important staple foods in the country and across Africa (Aigbedion-Atalor *et al*., 2019; 2020; Borisade *et al*., 2017). Tomato production therefore is a major source of livelihood in Nigeria, providing sustainable job opportunities for over 10 million people along the value chain, especially among smallholder tomato growers cultivating 0.5 to 4 hectares (Oladejo and Oladiran, 2014). However, several factors, including pests and diseases, water availability, and climate variability, constrains production (Borisade *et al*., 2017; Sanda *et al*., 2018). Amongst these factors, invasion of the South American tomato pinworm, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) to Nigeria in 2016 is one of the most damaging to tomatoes (Aigbedion-Atalor *et al*., 2019; Borisade *et al*., 2017). Although *T. absoluta* feeds and completes its development on a wide range of host plants, especially Solanaceae, it prefers tomatoes (Desneux *et al*., 2010). It can feed on virtually all parts of the shoot system of tomato, and yield loss is resultant of the disruption of the plant's photosynthetic process by the larvae feeding on leaves, and all four larval instars are destructive (Desneux *et al*., 2010; Biondi *et al*., 2018). Like all ectotherms, environmental conditions such as temperature substantially regulate its development and all aspects of its phenology. However, it is cold and heat tolerant, with thermal thresholds ranging between 14°C and 34.6°C (Krechemer and Foerster, 2015). Thus, when host plant species are available in suitable climatic conditions, *T. absoluta* exhibits high multivoltinism, producing over 12 generations annually without diapause (Biondi *et al*., 2018; Desneux *et al*. 2010). Its long range spread and means of introduction into novel environments have been

attributed almost entirely to anthropogenic-mediated influences, notably global trade and climate change (Desneux *et al*., 2010; Campos *et al*., 2017; Biondi *et al*., 2018). However, aspects of its biology, including its homodynamic and multivoltine behavior, its high reproductive capacity – one female can lay about 260 eggs in her lifetime – as well as its ability to evolve resistance to several insecticides are crucial drivers of its invasive success (Uchoa- Fernandes *et al*., 1995; Zekeya *et al*., 2017). The cumulative impact of these attributes, plus the lack of effective natural occurring enemies of the pest in tomato agroecosystems make management strategies of *T. absoluta* complex. Like all areas in the Afrotropical and Palearctic regions where *T. absoluta* is invasive, the impacts of *T. absoluta* in Nigeria are profound and can result in 100% yield loss, if left untreated (Oke *et al*., 2020a, 2020b; Bala *et al*. 2019). For example, in only one growing season in Kano State (one of the major tomato producing States in Nigeria) in 2016, over 2 billion Nigerian Naria (US $ 5,585,822, US $ 1 equivalent to 357 Naria) was lost due to *T. absoluta* (Bala *et al*. 2019; Sanda *et al*., 2018; Oke *et al*., 2017). The high yield losses countrywide resulted in the shutdown of the largest tomato processing factory in Nigeria, resulting in significant losses of livelihood (Bala *et al*., 2019). *Tuta absoluta* invasion in Nigeria coincided with the outbreak of the Ebola virus in West Africa, in late 2014 and 2015, and earned it the nickname 'Tomato Ebola' due to the similarity in the spread and impact of both organisms in the region (Borisade *et al*., 2017). Since then, tomato growers have relied on applying synthetic chemical insecticides as the primary management strategy for the pest. However, the excessive use of these chemicals is harmful to non-targets/beneficial organisms (Desnuex *et al*., 2022) and human health due to the lack of protective gear during applications and residues in fruit. Also, *T. absoluta* has evolved resistance to almost all insecticides used for control in Nigeria, thus requiring the development of new insecticide active substances (Guedes *et al*., 2019). However, since 2016 the National Horticultural Research Institute (NIHORT) in Ibadan, Oyo State, Nigeria, has heavily invested in developing integrated pest management (IPM) strategies to manage its devastating impacts on smallholder growers and food security in the country. These efforts have resulted in a simple, effective, and sustainable technology called the insect Trap Tray Technology (TTT), which can attract, trap and kill more than five thousand adults per trap. Also, two biopesticides, the NIHORT-Raktin and NIHORT-Lyptol, that can kill all life stages of the pest have been developed. However, there is dearth of information on naturally occurring enemies of *T. absoluta* in Nigeria, yet important for developing biological control programmes that may control the pest. Therefore, this study aimed to investigate the occurrence, distribution, and abundance of natural enemies of *T. absoluta* in Nigeria the rationale of designing biological control strategies to increase the IPM options of *T. absoluta* in Nigeria where its impacts are unrelenting, increasing poverty and food shortage.

MATERIALS AND METHODS

Insect collection and rearing

Surveys were conducted in tomato farms in northern Nigeria in 2019. We selected four local government areas each from four major tomato producing states in northern Nigeria: Jigawa, Kaduna, Kano and Katsina states (Figure 1). Five smallholder tomato grower farms (1 acre – 5 acres) were sampled per local government area. In most (95%) of the farms sampled, tomatoes were grown largely in a monocropping farming system and the age of the tomato plants sampled ranged between 2 weeks after transplant and plants that were being harvested at 14 weeks old fruit harvesting. Whole plants and leaves were sampled for *T. absoluta* infestation in a 5 m sampling area in each farm. Sampling occurred every fortnight from February, March and April 2019. *Tuta absoluta* Infested leaves were collected and placed in sealed airtight plastic paper bags, sealed with parafilm, and taken to the laboratory at NIHORT, Ibadan, while infested whole plants were transplanted into pots (filled with soil) in a cage and then transported to the laboratory. Leaf samples were transferred from the plastic bags to small plastic boxes. Intermittent resupplies of tomato leaves were made to support the development of the larval stage of *T. absoluta.* All samples were labelled individually according to the location/farms where they were collected. The laboratory was maintained at 26±2 °C, 60±10% RH, and L12:D12 photoperiod.

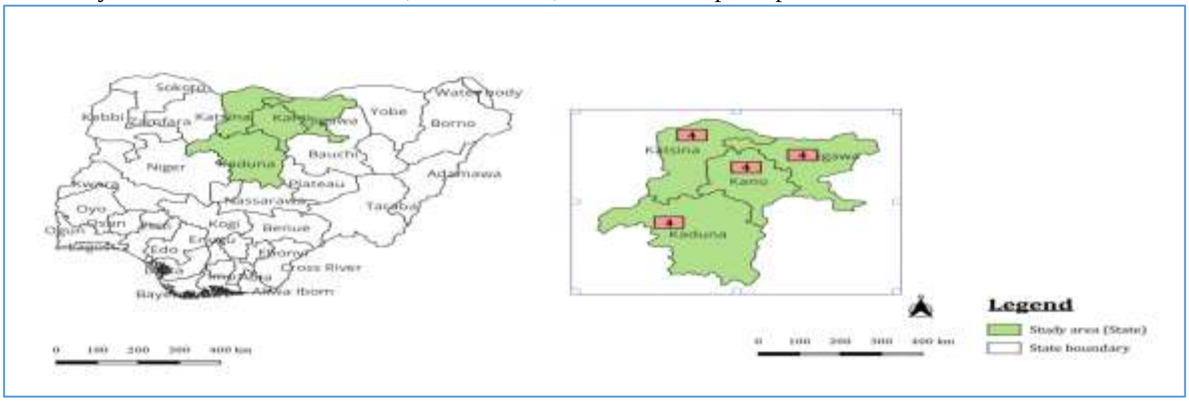

Figure 1: Map showing the study area (States) where sampling was conducted in four States in northern Nigeria. Numbers in pink-shaded boxes indicate the number of local Governments Areas that were sampled in each State.

Abundance of natural enemies

Parasitoids and predators that emerged from field samples collected in each of the four local government areas in the four study states were counted, recorded, and then preserved in 95% ethanol. Identification was done at the insect museum of NIHORT, Ibadan. We grouped the abundance of parasitoids or predator/5m/ acre in each farm/local government area as follows: Very abundant = 20-50, Moderately abundant = 10-20, Abundant = 5 – 10, Few = 1-5, and None = 0

RESULTS

Natural enemies

Based on morphological characteristics, ten predators and eight parasitoids were recorded. The predators included: *Podisus nigrispinus* (Dallas) (Hemiptera: Pentatomidae), *Zelus* spp (Hemiptera: Reduviidae), *Blaptostethus pallescens* (Poppius) (Hemiptera: Anthocoridae), *Xylocoris* spp (Hemiptera: Lyctocoridae), *Debilia* spp. (Hemiptera: Reduviidae), *Dicyphus errans* (Wolff) (Hemiptera: Miridae), *Macrolophus pygmaeus* (Rambur) (Hemiptera: Miridae), and *Nesidiocoris tenuis* (Reuter) (Hemiptera: Miridae) *Tapinoma nigerriumu* (Nylander) (Hymenoptera: Formicidae), *Pheidole* spp (Hymenoptera: Formicidae) (Table 1). .The parasitoids recorded were *Trichogramma* spp (Hymenoptera: Formicidae), Cryptinae spp. (Hymenoptera: Ichneumonidae), *Diadegma* spp. (Förster) (Hymenoptera: Ichneumonidae) *Bracon spp*. (Fabricius) (Hymenoptera: Braconidae), *Apanteles spp.* (Förster) (Hymenoptera: Braconidae)*Cotesia spp.* (Cameron) (Hymenoptera: Braconidae), *Diglyphus spp.* (Förster) (Hymenoptera: Eulophidae) and *Necremnus spp*. (Thomson) (Hymenoptera: Eulophidae) (Table 1).

Table 1: Predators and parasitoids recovered from sampled *Tuta absoluta* infested tomato leaves in major tomatoes producing States of Nigeria in 2019

Species	Family	Order	Target stage	Agent type
Podisus nigrispinus	Pentatomidae	Hemiptera	Adult	Predator
Zelus spp.	Reduviidae	Hemiptera	Adult	Predator
Blaptostethus pallesce	Anthocoridae	Hemiptera	Larvae	Predator
Xylocoris spp.	Lyctocoridae	Hemiptera	Larvae	Predator
Debilia spp.	Reduviidae	Hemiptera	Larvae	Predator
Dicyphus errans	Miridae	Hemiptera	Egg and larvae	Predator
Macrolophus pygmaeus	Miridae	Hemiptera	Egg and larvae	Predator
Nesidiocoris tenuis	Miridae	Hemiptera	Egg and larvae	Predator
Tapinoma nigerriumu	Formicidae	Hymenoptera	Pupae	Predator
Pheidole spp.	Formicidae	Hymenoptera	Pupae	Predator
Trichogramma spp.	Trichogrammatidae	Hymenoptera	Egg	Parasitoid
Cryptinae spp.	Ichneumonidae	Hymenoptera	Larvae	Parasitoid
Diadegma spp.	Ichneumonidae	Hymenoptera	Larvae	Parasitoid
Bracon spp.	Braconidae	Hymenoptera	Larvae	Parasitoid
Apanteles spp. (Förster)	Braconidae	Hymenoptera	Larvae	Parasitoid
Cotesia spp. (Cameron)	Braconidae	Hymenoptera	Larvae	Parasitoid
Diglyphus spp. (Förster)	Eulophidae	Hymenoptera	Larvae	Parasitoid
Necremnus spp.	Eulophidae	Hymenoptera	Larvae	Parasitoid

Abundance

Tapinoma nigerriumu was very abundant across most of the farms sampled in the four States (Table 2). Similarly, *Pheidole* spp and *N. tenuis* were very abundant or moderately abundant, albeit occurring in few numbers or absent in some farms. *Podisus nigrispinus* and *Zelus* spp. were mostly abundant but *D. errans*, M. *pygmaeus*, *B. pallescens*, *Xylocoris* spp and *Debilia spp* were rarely or not found in each of the states sampled (Table 2).
The parasitoid species were generally low or absent across all four sampled States (Table 2).

Table 2: The abundance of predators observed on *Tuta absoluta* in major tomato producing States in Nigeria during the 2019 growing seasons

	Predators									
States and local governments	*Podisus nigrispinus*	*Zelus* spp.	*Blaptostethus pallescens*	*Xylocoris* spp	*Debilia* spp	*Tapinoma nigerriumu*	*Pheidole spp*	*Dicyphus errans*	*Macrolophus pygmaeus*	*Nesidiocoris tenuis*
Kaduna State										
Kurmin kogi	Abundant	Abundant	Few	Few	Few	V. Abundant	M. Abundant	Few	Few	M. Abundant
Bomo	Abundant	Abundant	Few	None	Few	V. Abundant	V. Abundant	None	None	V. Abundant
Kubau	Abundant	Abundant	None	Few	None	M. Abundant	M. Abundant	None	None	M. Abundant
Takalafia Soba	Few	Abundant	Few	None	None	M. Abundant	M. Abundant	None	None	M. Abundant
Katsina State										
Danja	Abundant	Abundant	Few	Few	Few	V. Abundant	V. Abundant	None	None	M. Abundant
Kafur	Abundant	Abundant	Few	Few	None	M. Abundant	V. Abundant	None	Abundant	M. Abundant
Beriberi	Abundant	Abundant	Few	Few	Few	V. Abundant	V. Abundant	Few	Few	V. Abundant
Malumfasi	Abundant	Abundant	Few	None	None	V. Abundant	Abundant	None	None	Abundant
Kano State										
Kura	Abundant	Abundant	None	Few	None	Abundant	Abundant	None	None	Abundant
Kadawa	Abundant	Abundant	Few	Few	Few	V. Abundant	M. Abundant	None	Few	V. Abundant
Bagwai	Abundant	Abundant	Few	Few	Few	V. Abundant	M. Abundant	Few	Few	M. Abundant
Garun Mallam	Abundant	Abundant	Few	None	None	V. Abundant	V. Abundant	None	None	Few
Jigawa State										
Hadejia	Abundant	Abundant	None	Few	None	M. Abundant	M. Abundant	Few	Few	M. Abundant
Jahun	Abundant	Few	None	None	None	Abundant	Abundant	None	None	Few
Birnin Kudu	Abundant	Few	Few	None	None	V. Abundant	M. Abundant	None	None	Abundant
Kazaure	Few	Few	Few	Few	None	V. Abundant	Abundant	None	None	Abundant

Abundance scoring scale: V. Abundant = (20 – 50), M. Abundant = (10 – 20), Abundant = (5 – 10), Few = (1 – 5) and None = (0). V. Abundant indicates: Very Abundant, while M. Abundant is: Moderately Abundant

Table 3: The abundance of parasitoids recovered on *Tuta absoluta* in major tomato producing States in Nigeria in 2019 growing seasons

	Parasitoids							
States and local governments	*Trichogramma* spp.	*Cryptinae* spp.	*Diadegma* spp	*Bracon* spp.	*Apanteles* spp.	*Cotesia* spp.	*Diglyphus* spp.	*Necremnus* spp
Kaduna State								
Kurmin kogi	None	Few	Few	None	Few	Few	None	None
Bomo	None	None	None	None	None	None	None	None
Kubau	None	None	None	None	None	None	None	None
Takalafia Soba	None	None	None	None	None	None	None	None
Katsina State								
Danja	None	None	None	None	None	None	None	None
Kafur	None	None	None	None	None	None	Few	None
Beriberi	Few	None	None	None	Few	None	None	Few
Malumfasi	None	None	None	Few	None	None	None	None
Kano State								
Kura	None	None	None	None	None	None	None	None
Kadawa	Few	None	None	None	Few	None	None	Few
Bagwai	None	None	None	None	Few	None	None	None
Garun Mallam	None	None	None	None	None	None	None	None
Jigawa State								
Hadejia	None	None	None	None	Few	None	None	None
Jahun	None	None	None	None	None	None	None	None
Birnin Kudu	None	None	None	None	None	None	None	None
Kazaure	None	None	None	None	None	None	None	None

Abundance scoring scale: V. Abundant = (20 – 50), M. Abundant = (10 – 20), Abundant = (5 – 10), Few = (1 – 5) and None = (0).

DISCUSSION

Biological control programmes search, explore, and use predatory insects and mites, parasitoids and nematodes, against target pests. Following *T. absoluta* invasion in Nigeria in 2015, there has been a paucity of the occurrence and abundance of natural enemies of the pest. Conversely, insecticides have been ubiquitously used. Yet, no apparent sign of the pest's pressure has been reported. In fact, it is believed that the founder population had already evolved resistance to synthetic chemical insecticides in South America prior to its invasion across AfroEurasia, including Nigeria. Hence, articulating the unrelenting increase in the population density of the pests despite the increasing frequency of insecticide application. The surveys that we conducted in this study revealed the presence of 18 potential natural enemies of *T. absoluta* in Nigeria. We found 10 predatory species and 8 parasitoids that have been reported elsewhere across South America and the invasion range of the pest. Considering the failure of insecticides, the current high infestation of *T. absoluta*, and the impacts on the socio-economic of the pest's damage in Nigeria, it may be prudent to consider developing biological control programmes with the natural enemies that we found. For example, the potential of *N. tenuis* and parasitoids in controlling populations of *T. absoluta* is well-documented. Aigbedion-Atalor *et al*., 2021, showed that *N. tenuis* can substantially reduce the population of *T. absoluta* either alone or together with a braconid wasp, *Dolichogenidae gelechiidivoris* (Marsh) (Hymenoptera: Braconidae), imported into Kenya for the first classical biological control of *T. absoluta* in Africa. Chailleux *et al*. (2013) underscored the potential of combining *M. pygmaeus* and *Trichogramma* spp for the control of *T. asboluta*. These authors showed that although intraguild predation (IGP) is inflicted on *Trichogramma achaeae* by *M. pygmaeus* when these natural enemies are combined, the risk of IGP depends on the developmental stage of *T. achaeae* inside the egg because the larva is at risk mostly early in its development (when parasitized egg is still yellow). Further, Chailleux *et al*. (2013) highlighted that non-consumptive event, likely probing of the predator on parasitized eggs, may induce mortality in parasitoid offspring without actual feeding on parasitized eggs and that both IGP and non-consumptive events decreased when *M. pygmaeus* was not confined with parasitized eggs in small arenas. The latter authors concluded that despite the negative effects of the *M. pygmaeus* to *T. achaeae*, the addition of *Trichogramma* parasitoids may significantly increase the level of control of *T. absoluta* over what could be attained when only the mirid predator *M. pygmaeus* is present on tomato. Augmentation biological control, using the natural enemies recorded in this study, against *T. absoluta* in Nigeria could be considered. Fundamentally, augmentation refers to all forms of biological control in which natural enemies are periodically introduced, and usually requires the commercial production of the released agents (van Lenteren 2000). Through inundative or inoculative releases, or both, the pest's pressure may be reduced, and tomato yield increased.

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INSECTICIDAL EFFICACY OF *MORINDA LUCIDA* BENTH AQUEOUS EXTRACTS IN REDUCING POD-SUCKING BUG *RIPTORTUS DENTIPES* (HEMIPTERA: COREIDAE) INFESTATION AND DAMAGE ON COWPEA

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ABSTRACT
Production of cowpea is significantly hampered by insect pest infestations and farmers typically use synthetic insecticides to control them. The effectiveness of Morinda lucida leaf and bark crude extracts against the post-flowering (pod sucking) Riptortus dentipes insect pest of cowpea was tested in a field experiment that was set up in a complete randomized block design and replicated three times. The number of damaged pods, the total weight of harvested pods (g), and the total pod yield (kg/ha) were all summed after the cowpeas were sprayed at 6, 7, 8, and 9 weeks during seed filling to provide information on the insect population. Results indicated that spraying leaf (2.08) and bark (1.75) M. lucida extracts on cowpeas considerably reduced the R. dentipes population compared to untreated plots. Cowpea obtained from untreated plots had the highest pod damage (4.2), while cowpea treated plots with bark extract had the least (1.08) pod damage. Cowpea plots treated with leaf extracts (3.03) considerably outperformed those treated with bark extracts (p > 0.05). A similar trend was observed in terms of overall pod yield. The highest yield (730 kg/ha) was recorded on cowpea plots treated with bark extract, followed by leaf extract (480 kg/ha), while the lowest yield (198.70 kg/ha) was obtained from the control. The findings made it abundantly evident that M. lucida extracts might be potential insecticidal agents to offer beneficial alternatives to chemical management of insect infestations on cowpeas. The active ingredient be isolated and its potency be evaluated on post-flowering sucking bugs.
Keywords: *Bark extracts, insecticidal agents, Morinda lucida, pod damage, post-flowering, Riptortus dentipes*

INTRODUCTION
Cowpea contains equivalent protein quality and quantity to pricey animal protein and may be used as its substitute. It provides elements that are lacking in grains and is a vital component of many households' meals in Africa, Latin America, and Asia. In actuality, all amino acids required for human nutrition—aside from sulphured amino acids—are present in cowpea seeds (Adesina, 2014).
The production and consumption of cowpea is constrained in Nigeria despite its nutritious value because of a variety of insect pest infestations. About 30% of the annual production is thought to be lost to insect pests (Adesina and Enudeme, 2018). According to Rabindra *et al.* (2004), 2.5 to 3.0 million metric tons of pulses are lost annually as a result of pest issues. Complete crop failure is possible, particularly when management methods are not used. However, when insects are managed using pesticides, cowpea output in Nigeria can be increased and increased tenfold (Ajeigbe and Singh, 2006).
The major insect pests known to attack cowpea at pre-flowering, flowering, and post-flowering stages are; *Seriesthrips occipitalis, Taeniothrips sjostdti, Maruca testulalis, Acythomyia horida, Riptortus dentipes,*

Anoplocnemis curoipes and *Cydia ptychora* causing damage from 50%, 20% and 35% (IITA, 1973) i.e., over 90% potential stage (Raheja, 1976).

The most popular control method has been the use of synthetic insecticides, which have caused a number of issues that were not anticipated at the time of their introduction. These issues include the acute and chronic poisoning of applicators, farmworkers, and even consumers; the extinction of fish, birds, and other wildlife; the disruption of natural biological control agents and pollinators; extensive groundwater contamination that may endanger human and environmental health and the evolution of resistant insects. (Md. Wasim *et al.,* 2009; Maurya et al., 2019; Pathak et al., 2022). Researchers from all over the world are looking for alternatives to chemical pesticides as a result of the numerous concerns connected to their use. pesticides made from plants have long been promoted as appealing substitutes for manmade chemical pesticides (Echereobia *et al.,* 2010). The use of plant extracts in the control of insect pests is advantageous for management of the pest population and the preservation of a healthy ecological balance. Therefore, the goal of this study is to assess *Morinda lucida* bioefficacy in combating the cowpea pest *Riptortus dentipes*, which is a post-flowering (pod-sucking) bug.

MATERIALS AND METHODS

Study Area and Land Preparation: During the 2022 growing season, the experiment was carried out in the Rufus Giwa Polytechnic Teaching, Research, and Commercial Farm in Owo, Ondo State, Nigeria (7° 11' 43" N, 5° 33' 57" E). Prior to the trial, maize was grown on the test plot. To achieve an idyllic location tilth, the plot was disc ploughed, harrowed and ridged.

Plant extracts Preparation: Fresh *Morinda lucida* stem bark and leaves were obtained from the Polytechnic neighbourhood, cleaned with clean water to remove any dirt, and then left to drain. 1 kg of each plant material was weighed using an electronic balance, thoroughly crushed with a mortar and pestle to produce finely grounded materials, and then soaked in 1.5 litres of water in a plastic bucket, left overnight with occasional stirring to form a thorough mixture. The mixture was then filtered the next day with 1.5 litres of water using a muslin cloth. After that, the aqueous extracts were set for use (Oparaeke, 2005).

Crop establishment and Field Layout: Three treatments; 10% v/v crude aqueous extracts of *M. lucida* leaf, back, and control (without insecticide)—were used in the field experiment, which was set up using a Randomized Complete Block Design (RCBD) and replicated three times for each treatment. Each treatment was assigned to a 5-by-5-meter plot, with three main rows and two discard rows (one on either side of the main rows) in each plot size. To check for spray drift, a 1.0-meter-wide border margin was placed between each plot. A week after planting, supply was carried out by sowing two seeds of the indigenous cowpea variety Kano white in each hole with a 60cm x 60cm spacing. Between 3 and 6 weeks following planting, weeding was done. Following bug sampling with a knapsack sprayer once a week for four weeks, starting from flower bud initiation or onset, the leaf extracts were administered between 8 and 10 am (that was the time when the insects were less active). of flowering.

Data Collection and Analysis: Insect pests were visually counted from the middle row of each plot at the time of 60% formation of buds and flowers in the early morning hours of 6–7 a.m. to determine the effectiveness of aqueous plant extracts in reducing insect infestation and damage to cowpeas. Additionally, the insect count was done 3 and 7 days (DAS) following each spraying. Data on the number of infested (damaged) pods, the number of harvested pods, and the weight of the grain were collected at 5-day intervals when the pods displayed indicators of maturity. ANOVA was used to analyze the acquired data, and a Duncan's Multiple Range Test (DMRT) with a 5% significance level was used to distinguish the significant treatment means.

RESULTS

At the conclusion of the experiment, the cumulative pod-sucking insect population on cowpeas treated with *M. lucida* extracts showed that the insect population on cowpeas in the control and leaf extract-treated plots did not differ significantly Figure 1). On the other hand, cowpea plots treated with bark extract, had the least population of bugs (1.75). The outcome in Figure 2 demonstrates that the aqueous extract significantly ($p > 0.05$) reduced pod damage by pest insect species that feed on pods compared to the untreated check. Cowpeas in the control plot had the considerably highest ($p > 0.05$) pod damage (4.2), whereas cowpeas treated with bark extract had the least pod damage.

Table 1 shows how insecticidal plant extracts affect pod weight (kg) and overall pod production. According to the results, cowpeas treated with bark extract had the highest pod weight (677g), while those without insecticidal control had the lowest pod weight. However, the pod weight of cowpeas treated with leaf and bark extracts differs noticeably from one another. Regarding the overall pod yield, a similar pattern was seen. The highest yield (730 kg/ha) was recorded by cowpeas treated with bark extract, followed by leaf extract (480 kg/ha), while the lowest yield (198.70 kg/ha) was obtained from the control.

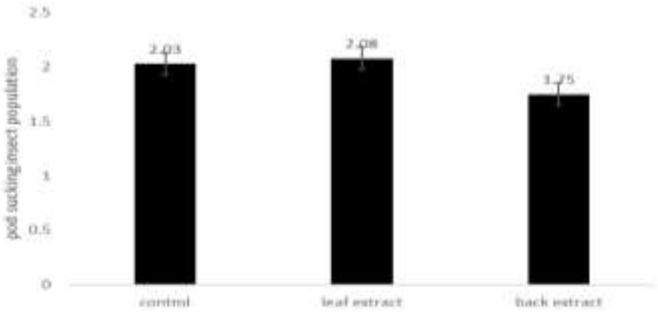

Figure 1: Effect of leaf and bark extracts of *Morina lucida* on pod sucking insect population

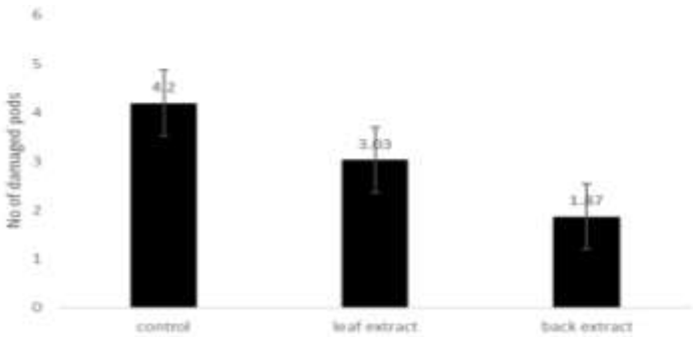

Figure 2: Effect of leaf and bark extracts of *Morina lucida* on pod damaged

Table 1: Effect of leaf and bark extracts of *Morina lucida* on cowpea yield

Treatments	Pod weight (g)	Total pod yield (g/ha)
Control	261.0a	198.7a
Leaf extract	600b	480.0b
Bark extract	677a	730a

Treatments with a different alphabet in the same column are significantly different using DMRT at a 5% probability

DISCUSSION

For many centuries, farmers with few resources in low-income countries have utilized plant-based pesticides to manage insect pests of both field crops and conserved products. Nevertheless, many scholars have documented the effectiveness of various plant components as biopesticides for the management of various insect species (Oparaeke 2004).

The findings of the current study showed that cowpea pod-sucking bugs' population and damages was decreased by using aqueous bark extracts of the tested plants. According to Owolade *et al.* (2004), Adesina and Afolabi (2014), Adesina and Ileke (2014), Adesina *et al*. (2016a), Adesina *et al*. (2016b), and Adesina and Enudeme (2018), who reported the effectiveness of many botanical extracts in the management of various insect pests of crops and the population suppression ability of the plant extracts, suggested that the plant materials possess insecticidal properties. It is unclear exactly how the aqueous leaf extracts work to reduce the bug population in cowpeas. It might, however, be the outcome of contact activity or perhaps it was due to an antifeedant or repellent effect. Insects did not perch on the leaf surfaces following treatment applications, according to visual inspection of the treated plots. This corroborates the report of Stoll's (2000) that one of the main mechanisms by which aqueous plant extracts reduce insect damage to crops is by repellency.

Comparison among all treatments, revealed that the yields from sprayed plots and plant extracts were better. This finding is consistent with earlier research report by Nderitu *et al.* (2008), who found that aphid infestations can cause significant yield losses in the absence of insecticides. The outcome supported earlier studies' results that plant extracts boost vegetable and pea plant yields by shielding them from insect pests (Stoll 2000).

CONCLUSION

Due to the phytochemicals perceived in the extracts, the study demonstrated that *M. lucida* plant extracts had strong insecticidal properties in controlling cowpea post-flowering insect pests and boosted cowpea productivity. As a result, it is hereby recommended that cowpea farmers in the research area adopt *M. lucida* bark aqueous extracts as a potential substitute for synthetic insecticides.

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4-CHLOROPHENOXY ACETIC ACID (4-CPA) ROLE ON YIELD OF TOMATO UNDER VARYING PLANT DENSITY DURING RAINY SEASON IN SUDAN SAVANNA OF NIGERIA

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ABSTRACT
The aim of the research was to investigate the efficacy of 4-chlorophenoxy acetic acid at varying plants density. Field trials were therefore conducted during the rainy season of 2020 at Bayero University Teaching and Research Farm and Audu Bako College of Agriculture Demonstration Farm Dambatta. The treatments consisted of three population density (22,222, 26,666 and 33,333 plants ha^{-1}) and four concentrations of 4-CPA (0, 50, 75 and 100 mgL^{-1} of distilled water). The experiment was laid out in a Split Plot Design and replicated three times. The data collected on yield and yield components were subjected to analysis of variance. The result showed that 4-CPA had significant effect on fruit length, fruit diameter, marketable fruit yield and total fruit yield. Plant population density was observed also to significantly influence total fruit yield and marketable fruit yield. Based on the findings of the study, it was suggested that farmers in the areas of study can be advised to grow UC82B tomato and apply 4-CPA at a density of 22,222 plants ha^{-1} for higher yield of the crop during rainy season.
Keywords: *Tomato, Plant density, 4-Chlorophenoxy acetic acid, Fruit yield*.

INTRODUCTION
Tomato requires a relatively cool and dry climate for high yield and premium quality. Tomato production is mainly under field condition, where changes in climatic conditions especially high temperature, high humidity, rainfall, pests and diseases does not allow the realization of full economic yield of the crop. However, it is adapted to wide range of climatic conditions from temperate to hot and humid tropical environment, with optimum temperature for growth in the range of 20 – 27 °C (Grubben and Denton, 2004). Moreover, marked prohibition of photosynthesis happens at temperatures above average, causing remarkable decrease in yield. Therefore, improved agronomic practices with potential for reducing the effect of high temperature and humidity for high yield of tomato especially during the wet and dry seasons should be investigated in order to meet up with the all year round demand of the crop. Several reports indicated increased fruit size and fruit setting in tomato due to manipulation of plant population density and application of plant growth regulators such as 4-chlorophenoxy acetic acid (Tomatotone) and 2, 4-dichlorophenoxy acetic acid (2, 4-D) (Ozguven, 2000). It is with all that in mind that the research was conceived with the aim of determining the effect of 4-Chlorophenoxy acetic acid (4-CPA) and population density on yield of tomato under rain-fed condition.

MATERIALS AND METHODS
The research was conducted during the 2020 rainy seasons at two locations, Research and Teaching Farm of Faculty of Agriculture, Bayero University Kano (BUK) which lies on latitude 11^{0} 97' 98.6'' N and longitude 8^{0} 42' 03.7'' E and 475 m above the sea level and demonstration Farm of Audu Bako College of Agriculture, Dambatta (DBT) which lies on latitude 11^{o} 83' 40.3'' N and longitude 08^{o} 10' 33.9'' E and 418 m above the sea level all within the Sudan Savanna Zone of Northern Nigeria. The treatments were on RomaVF variety which consists of three different spacing of 75 x 60 cm, 75 x 50 cm and 75 x 40 cm inter and intra row spacing to obtain the plant population densities of 22, 222, 26, 666 and 33, 333 plants ha^{-1} respectively as dictated by the treatment combination and four concentrations of 4-Chlorophenoxy acetic acid, (0, 50, 75 and 100 mgL^{-1} of distilled water). The experiment was replicated three times and laid out in a Split Plot Design with population density assigned to the main plots, while 4-CPA was assigned to the sub plots. Seedlings of UC82B variety were raised using seed beds until they were ready for transplanting at 6 weeks old. The 4-CPA treatment was applied after it was prepared by mixing 0, 50, 75 and 100 mg of 4-CPA powder L^{-1} of distilled water and two drops of baby shampoo were

added to enhance stickiness of the 4-CPA on the flowers as recommended by (Baliyan *et al*., 2013). The mixtures were later applied to the flowers after few flowers had opened, about 1 ml per flower cluster was applied using hand held sprayer in the morning as from 8 am as recommended by Asian Vegetable Research and Development Center (AVRDC), (2001). Harvesting was done by hand picking at the time the fruits attained physiological maturity spanning four pickings. The data collected were subjected to analysis of variance using Genstat (17th Edition) and the means were separated using Fisher's Protected Least Significant Difference Test at 5% level of probability.

RESULTS

Table 1 shows the effect of 4 – CPA and population density on number of flower clusters plant^{-1} during 2019 rainy season at BUK and Dambatta. At both location population density effect on the number of flower clusters plant^{-1} was significant where the result recorded indicated population densities of 22,222 and 26,666 plants ha^{-1} were at par and produced significantly higher number of flower clusters plant^{-1} than population density of 33,333 plants ha^{-1}. However, the result showed no significant difference among the 4-CPA concentrations on number of flower clusters plant^{-1}.

Fruit length of tomato as affected by population density and 4-CPA concentrations during the 2019 rainy season at BUK and Dambatta is also shown in Table 1; the result obtained shows that difference in plant population densities was recorded to be significant on fruit length at both location the result obtained showed that 22,222 plant^{-1} had significantly longer fruits than 26,666 and 33,333 plants ha^{-1} which were statistically similar. Also the result revealed that application of 4-CPA significantly affected fruit length of tomato at BUK, 75 and 100 mgL^{-1} were at par in fruit length but 100mgL^{-1} was significantly higher in fruit length than 0, and 50 mgL^{-1} 4-CPA concentrations statistically similar also, while at Dambatta the result showed no significant difference among the 4-CPA concentrations on fruit length of the tomato. Also, Table 1 shows the fruit diameter of tomato as affected by population density and 4-CPA concentrations during 2019 rainy season at BUK and Dambatta. Population density significantly affected the fruit diameter in both locations, the result indicated that 22,222 plants ha^{-1} was significantly higher in fruit diameter than 26,666 and 33, 333 plants ha^{-1} which were at par with one another at BUK, while at Dambatta 26,666 and 22,222 plants ha^{-1} were at par but 22,222 plants ha^{-1} was significantly higher in fruit diameter than 33,333 plants ha^{-1}. However, at BUK the result revealed significant effect of 4-CPA concentrations on the fruit diameter, the result showed that 4-CPA concentrations of 50, 75 and 100 mgL^{-1} were statistically at par with another but recorded significantly higher fruits diameter than the control, but at Dambatta the result shows no significant effect of 4-CPAconcentrations on fruit diameter of the tomato.

Table 1: Number of Flower Clusters Plant-^{1}, Fruit Length (mm) and Fruit Diameter (mm) of Tomato as affected by 4-CPA and Population density during 2019 Rainy Season at Bayero University Kano and Dambatta

	Flower Clusters		Fruit Length		Fruit Diameter	
	BUK	DBT	BUK	DBT	BUK	DBT
Plant population (plant ha^{-1})						
22, 222	10.62^{a}	10.56^{a}	69.74^{a}	68.29^{a}	06.00^{a}	57.76^{a}
26,666	10.51^{a}	9.92^{a}	68.01^{b}	67.41^{b}	50.32^{b}	46.77^{b}
33,333	9.03^{b}	8.33^{b}	67.12b	67.47^{b}	49.51^{b}	48.79^{b}
P-value	0.036	0.040	0.006	0.009	0.050	0.015
SE$\pm$	0.878	0.138	0.034	0.149	0.562	0.380
4-CPA (mgL^{-L})						
0	10.45	10.10	68.28^{a}	68.87	47.53^{b}	47.78
50	10.11	9.97	66.63^{b}	69.02	50.95^{a}	48.71
75	11.00	10.66	70.70^{ab}	68.99	51.34^{a}	48.06
100	11.00	10.85	72.33^{a}	69.00	51.05^{a}	49.25
P-value	0.076	0.057	0.003	0.084	51.05^{a}	0.700
SE$\pm$	0.123	0.897	0.310	0.104	<.001	0.702
INTERACTION						
P X C	0.022	0.050	<.001	0.111	0.021	<.001

Means followed by the same letter(s) are not significantly different at 5% level of using Fisher's protected least significant difference test.

Table 2 showed the interaction between population densities and 4-CPA concentrations on fruit diameter of tomato in 2019 at Dambatta. Considering the population densities under 0 mgL^{-1} 4-CPA concentration there was no significant effects among the population densities, also under concentration of 50 mgL^{-1} 4-CPA the trend was the same, but under 75 mgL^{-1} 4-CPA, population densities of 33,333 and 26,666 plants ha^{-1} were statistically similar but significantly higher in fruit diameter (39.54 and 42.29 mm) than population density of 22,222 plants ha^{-1} (35.36 mm), while under 100 mgL^{-1} 4-CPA , there was no significant effect among the population densities. Looking at 4-CPA concentration under population density of 33,333 plants ha^{-1}, there was no significant effects among the 4-CPA, while under population density of 26,666 ha^{-1}, 50 , 75 and 100 mgL^{-1} 4-CPA were all at par but 75 mgL^{-1} was significantly higher in average fruit diameter (42.29 cm) than 0 mgL^{-1} 4-CPA, average fruit diameter of 35.96 cm, but under population density of 22,222 plants ha^{-1} 0, 50 and 75 mgL^{-1} 4-CPA were at par with each other but 50 mgL^{-1} was significantly higher in fruit diameter (39.58 cm) than 75 mgL^{-1} 4-CPA fruit diameter of 35.36 cm.

The interaction between population densities and 4-CPA concentrations on average fruit length of tomato in 2019 at Dambatta was also presented on Table 2. Studying the population densities under 0 mgL^{-1} 4-CPA, population density of 22,222 plants ha^{-1} was significantly higher in fruit length (8.26 cm) than 33,333 plants ha^{-1} which was also higher (7.60 cm) than 26,666 plants ha^{-1} (6.85 cm), while under 50 mgL^{-1} 4-CPA, population densities of 22,222 and 33,333 plants ha^{-1} were at par with one another but 22,222 plants ha^{-1} was significantly higher in fruit length (8.57 cm) than population density of 26,666 plants ha^{-1}, but under 75 mgL^{-1} 4-CPA all the population densities were at par in average fruit length, while under 100 mgL^{-1} 4-CPA the trend was also similar to that of 75 mgL^{-1}. Looking at the 4-CPA under population density of 33,333 plants ha^{-1}, 50 and 75 mgL^{-1} were statistically similar but 75 mgL^{-1} was significantly higher in fruit length (8.38 cm) than100 mgL^{-1} which was also higher (7.77 cm) than 0 mgL^{-1} 4-CPA, while under population density of 26,666 plants ha^{-1}, 100, 75 and 50 mgL^{-1} 4-CPA were at par but significantly higher (7.79, 7.93 and 7.59 cm) than the control (6.85 cm) fruit length, but under population density of 22,222 plants ha^{-1} the result showed that all the 4-CPA concentrations were statistically at par in fruit length.

Table 2: Interaction between Population Densities (ha^{-1}) and 4-CPA (mgL^{-1}) on Average Fruit Diameter (mm) and Fruit Length (cm) of Tomato during 2019 Rainy Season at Dambatta.

Treatment Population Density 4-CPA Concentration	Diameter			Length		
0	38.36^{bcd}	35.96^{cd}	37.27^{bcd}	8.26^{abc}	6.85^{e}	7.60^{d}
50	39.05^{abc}	40.52^{ab}	39.58^{ab}	8.57^{a}	7.59^{d}	7.88^{a-d}
75	39.54^{ab}	42.29^{a}	35.36^{d}	8.21^{a-d}	7.93^{a-d}	8.38^{ab}
100	38.20^{bcd}	39.27^{abc}	37.27^{bcd}	8.30^{abc}	7.79^{bcd}	7.77^{c}
SE±			1.163			0.330

Means followed by the same letter(s) are not significantly different at 5% level of significance using Fisher's protected least significant difference test.

Table 3 revealed the Marketable fruit yield t ha^{-1} of tomato as affected by population density and 4-CPA concentrations during the 2019 rainy season at the two locations of the trial. Marketable fruit yield was significantly affected by population density at both locations of the trials, the result indicated that at BUK, 22,222 plants ha^{-1} was significantly higher in marketable fruit yield than 26,666 and 33,333 plants ha^{-1} which were at par with one another, while at Dambatta, 22,222 plants ha^{-1} was significantly higher than 26,666 plants ha^{-1} which in turn was significantly higher than 33,333 plants ha^{-1}. Furthermore, Marketable fruit yield t ha^{-1} was significantly affected by application of 4-CPA, the result indicated that at both locations, 100 and 75 mg L^{-1} 4-CPA concentrations were at par with one another but significantly higher in marketable fruit yield than 50 mg L^{-1} 4-CPA which was in turn higher than 0 mgL^{-1} which was the control.

Non Marketable fruit yield t ha^{-1} of tomato as affected by population density and 4-CPA concentrations during the 2019 rainy season at the two locations of the trial is shown on Table 3 also, the result revealed that Non Marketable fruit yield t ha^{-1} was not significantly affected by population density at both BUK and Dambatta, but was significantly affected by 4-CPA concentrations; at BUK, 4-CPA concentration of 75 mgL^{-1} was significantly higher in non-marketable fruit yield than 4-CPA concentrations of 100, 50 and 0 mgL^{-1} which were at par with one another, while at Dambatta there was no significant difference among the 4-CPA concentrations. Table 3 also showed the total fruit yield (t ha^{-1}) of tomato as affected by population density and 4-CPA concentration during the 2019 rainy season at the two sites of the trial. Total fruit yield in tons ha^{-1} was significantly affected by population density. The result recorded indicated that at the two sites; 22,222 plants ha^{-1} was obtained to be significantly higher in total fruit yield than 26,666 and 33, 333 plants ha^{-1} statistically at par with one another. Total fruit yield in tons ha^{-1} was also significantly affected by 4-CPA application; the result indicated that 4-CPA at 100 mgL^{-1} concentration was significantly higher than 4-CPA concentrations of 75 and 50 mg L^{-1} which were statistically at par with one another but significantly higher than 0 mg L^{-1} concentration.

Table 3: Fruit Yield (t ha^{-1}) of Tomato as affected by 4-CPA and Population density during 2019 Rainy Season at Bayero University Kano and Dambatta.

	Marketable Yield		Non Marketable Yield		Total Yield	
	BUK	DBT	BUK	D BT	BUK	DBT
Plant population (plant ha^{-1})						
22, 222	13.50^{a}	11.90^{a}	0.21	0.12	17.49^{a}	13.66^{a}
26,666	10.07^{b}	9.77^{b}	0.31	0.07	14.96^{b}	11.08^{b}
33,333	09.97^{b}	9.03^{b}	0.24	0.09	12.85^{b}	09.77^{c}
P-value	</001	<.001	0.076	0.082	0.003	0.005
SE±	0.362	0.357	0.845	0.762	1.092	0.367
4-CPA						
0	10.81^{c}	9.31^{c}	0.21^{b}	0.11	11.02^{c}	09.42^{c}
50	13.46^{b}	11.78^{b}	0.22^{b}	0.09	13.68^{b}	11.96^{b}
75	14.36^{a}	13.18^{ab}	0.18^{b}	0.07	14.54^{b}	13.26^{b}
100	17.45	15.45^{b}	0.33^{a}	0.13	17.78^{a}	15.58^{a}
P-value	<.001	0.005	0.048	0.059	0.008	0.005
SE±	1.204	0.067	0.004	0.007	0.910	0.672
INTERACTION						
P X C	0.829	0.402	0.726	0.367	0.816	0.400

Means followed by the same letter(s) are not significantly different at 5% level of using Fisher's protected least significant difference test.

DISCUSSION

Effect of Population Density on Growth and Yield of Rain Fed Tomato.

The Fresh yield per plant was found to be higher on the low population density of plant ha^{-1} during the trials and this could be attributed to the availability of more space for nutrients and sunshine exploitation by the tomato which was in line with the findings of Papadopoulos and Pararajasingham (1997) who in their studies reported that high plant densities have been shown to have detrimental effect on assimilate partitioning, because of an inadequate supply of photosynthates due to increase in shading. Also Baloch *et al.* (2002) observed that lowering plant densities increased the nutrient area per plant and this led to an increase in agronomic characters such as fruits diameter and yield. Schomaker and Been, (2006), observed that plant population density plays an important role in increasing or decreasing the yield of crop per unit land area, the result of the study indicates that plant population density of 22,222 plants ha^{-1} had significantly higher marketable and total fruit yield in the two successive years of the trials at both locations. The result obtained is in harmony with what was reported by Uko *et al*, (2013) and Baloch *et al.* (2002) that low plant density recorded more fruit number and highest fruit diameter and weight than high plant population density.

Effect of 4-CPA on Yield of Rain Fed Tomato

The result of the study showed that application of 4-CPA significantly increases the total fruit yield of tomato at both locations, higher fruit yield was obtained with application of 100 mgL^{-1} 4-CPA. This could be attributed to the ability of the 4-CPA to enhance flower retention by the plant resulting to more fertilized flowers without much abscission and high fruit retention. This result was supported by the findings of Asian, Vegetable Research and Development Center (AVRDC, 2012), Nandwani *et al.* (2014), Ozguven (2000), Baliyan *et al.* (2013) and Lathiya and Sanjeev (2017) who reported that application of plant growth regulators has been shown to improve fruit setting in tomato, they further reported that sprays of hormone especially 4-chlorophenoxy acetic acid on flower cluster effectively increase the fruit set as well as fruit production. Also Karim *et al.* (2015) had shown that application of 4-CPA induced higher number of fruit set to some extent. It was further reported that application of plant growth regulators increased fruit set of summer tomato (Rahman *et al.*, 2015). 4-CPA is also used in reducing pre-harvest fruit drop and resulting in increased number of fruits and yield in tomato crop. Meliha *et al.*, (2006), further revealed that the growth regulating substances used increased the number and size of fruits of tomato and their fresh and dry weights with 4-CPA being most effective.

CONCLUSION

From the result of this study, it can be concluded that; Tomato responded positively to 4-CPA application and population density where the highest yield was recorded with plant population density of 22,222 plants ha^{-1} due to application of 100 mgL^{-1} 4-CPA concentration. Therefore, based on the findings of this study, it can be suggested that farmers in the areas of study can be recommended to grow tomato and apply 4-CPA at 100 mgL^{-1} of distilled water in order to increase fruit yield of the crop during rainy season.

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PROCEEDINGS OF THE

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Agricultural Society of Nigeria

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Federal University of Lafia, Nasarawa State

“LAFIA”

SUB-THEME 8:

Enhancing Food Security through Post-Harvest Management

EVALUATION OF THE REPELLENT AND TOXICITY EFFICACY OF THREE EDIBLE ESSENTIAL OILS AGAINST THE RICE WEEVIL, *SITOPHILUS ORYZAE* (L.) [COLEOPTERA: CURCULIONIDAE] INFESTING PADDY

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ABSTRACT

The three edible essential oils (EEO), clove, Syzgium aromatic (L.) Meril and Percy; West African Black pepper (WABP), Piper guineense Schum and Thonn. and ginger, Zingiber officinale Rosc. were evaluated to determine their repellency and toxicity effect to adult Sitophilus oryzae on ten paddy rice varieties using the Petri dish chamber test on each of the paddy. Four concentrations of the different edible essential oils (EEO) were prepared by dissolving 0.25, 0.5, 0.75 and 1.0 mg each in 2 ml analytical grade acetone while the control was treated with 2 ml pure analytical grade acetone. Before the introduction of test insects into the Petri dishes, the acetone used as the carrier was allowed to evaporate completely. Thereafter, 30 unsexed adult S. oryzae that were 2 - 3 days old was released at the center of the Petri dish and then covered with the lid. The number of insects present in treated and untreated discs was recorded after 30 minutes and 24 hours respectively. The experiment was laid down in a complete randomized designed (CRD) and replicated three times. Data analyses was carried out in a one-way and two-way analysis. Probit analysis was carried out to determine the LC_{50} effect of the EEOs on S. oryzae. Edible essential oil extracted from clove, WABP and ginger were used to repel adult S. oryzae on paddy rice variety which showed varying degrees of repellency by these oils as observed in this study, repellency classes of III – V was achieved at concentrations of 0.25 – 1.00 mg/30 cm^2 using the different oils. The repellency effect of ginger oil was more effective in repelling the rice weevil than clove and WABP. The result of the LC_{50} showed that clove oil (LC_{50}= 0.358 mg/5 g) caused high mortality of adult weevil of compared to 0.531 and 0.658 mg/5 g for WABP and ginger oils, respectively.

Keywords: *Repellent; Toxicity; Syzgium aromatic; Piper guineense; Zingiber officinale; Sitophilus oryzae; Paddy*

INTRODUCTION

Rice (*Oryzae sativa* (L.) constitutes the world most used cereal and highly important staple for more than half of the people of the world's population (Fukagawa and Ziska, 2019). Nigeria production has risen from 4.78 million metric tons to 8.34 million tons in 2021 (KNOEMA, 2021). The two most commercially used cultivars are *Oryzae sativa* (L.) known as the Asian rice and *O. glaberrima* (Steaud) called the African rice (Tajuddin, 2014; Wambugu *et al*., 2021). As a nutritionally staple food recognized globally, rice plays an important role in the culture, diet and economies of millions of people around the world (Fukagawa and Ziska, 2019). The consumption of rice per capital in Nigeria was 32 kg, indicating 4.7% increase in the past decades (Okrent and Kumcu, 2016).

In an attempt to increase production in order to meet the food need of the growing population, farmers encountered a lot of challenges ranging from decrease in rainfall, reduction in yield due to abiotic stress, vulnerability of local rice varieties to pre and post- harvest diseases and insect pests from the field to store among others (Sinding, 2009; Norton *et al*., 2010). About 37% of rice grain yield is lost annually, resulting in 20-40% weight loss to insect pests and diseases (Mondal *et al*; 2017). In developing countries pest account for 15%-100% and 10-60% pre and post-harvest loses of grain respectively (Mihale *et al.*, 2009; Kumar and Kalita, 2017). The rice weevil, *S. oryzae* is the major insect pest of both paddy and milled rice in storage (Akhtar *et al*., 2015). It can damage the whole grain by feeding on the endosperm causing lost f weight, nutrient, quality, and reduces germinability of the seedling leading to loss of market value (Costa *et al*., 2016; Zakladnoy, 2018).

The losses incurred by farmer from insect pests' and diseases damage on rice, compel them to look out for effective control measure that will curtail the obnoxious pests, hence the use of synthetic pesticide with quick and broad spectrum in controlling insect pests (Tudi *et al*., 2021). The indiscriminate use of these synthetic pesticides have posed great concern about environmental hazard and economic sustainability due to paucity of fund as well as many species of insect pests developing resistance to the pesticide used over time (Zhu *et al*., 2016; Mahmood *et al*., 2016). Therefore, this research evaluated the repellent and toxicity efficacies of *Syzgium aromatic*, *Piper guineense* and *Z. officinale* against rice weevil, *S. oryzae* infesting paddy.

MATERIALS AND METHODS

Collection of Paddy Rice Varieties

Fifteen paddy rice varieties (FARO 17, FARO 20, FARO 22, FARO 27, FARO 30, FARO 31, FARO 32, FARO 37, FARO 30, FARO 44, FARO 50, FARO 57, FARO 60 and FARO 61) used for the experiment were obtained from the National Cereals Research Institute, Badeggi (NCRI), Niger State; and three local varieties Jamila, Lafia Sippi and Water proof were purchased from farmers in Lafia, Nasarawa State at the end of the 2020 harvest season. All paddy rice collected were stored in the freezer at -0ºC for 2 weeks in order to kill any insect eggs and adults that may have harbored inside the kernel (Ileke *et al.*, 2020). After 2 weeks, the rice paddy was put in the desiccator in order to dissipate any moisture that would have been absorbed by the kernel and kept in the laboratory cupboard in tightly sealed polypropylene sheet until needed for the experiment.

Sourcing and insect culturing of the rice weevil, *Sitophilus oryzae* L.

The initial parent stock of the rice weevil, *S. oryzae* used for the experiment were sourced from an already infested polished rice obtained from a Rice Merchants at Lafia market. This batch of insect was re-infested on 750 g of polished rice (Jamila variety) put in five different jars and kept in the Agronomy laboratory Faculty of Agriculture, Shabu-Lafia Campus Nasarawa State University, on 08. 33ºN and 0.8 32ºE, north central Nigeria (Lyam, 2000) under ambient temperature and relative humidity of 27ºC±2 and RH 65±3, respectively. Emerging adults from the culture was re-infested following the method described above for upwards of three generations in order to acclimatize the insects to laboratory conditions. Adult that emerged from the third generations were used for the study.

Procurement of edible spice plant materials

Dry 5 kg each of the seeds of clove, *Syzygium aromaticum*, West African Black Pepper, *P. guineense* and ginger rhizome, *Z. officinale* were purchased from Lafia market in Nasarawa State. Each of these spices were cleaned, and sorted in order to obtain dirt free materials. The edible spices were macerated in a mortar with a pestle and thereafter milled into a semi fine powder using a kitchen Kenwood® blender. Essential oils from the spices were extracted from the pulverized seeds of clove, West African black pepper and rhizome of ginger at the Science and Technology Complex Laboratory (SHETSCO) Sheda, Abuja FCT.

Processing of the edible essential oil

The edible essential oil was extracted from the semi-fine powders of clove, *Syzygium aromaticum*, West African Black Pepper, *Piper guineense* and ginger rhizome, *Zingiber officinale*, using a Glass Steam Essential Oil Distiller (Hydro distiller) model EME31000/CEB with a round bottom flask. The powder stock of clove, West African Black Pepper, and ginger were soaked with distilled water in a round bottom flask for 4 - 6 hours and heated for 1 hour at 100ºC. The extracted oil and water were removed from the receiving flask and the essential oil was transferred via a separating funnel. Each extracted edible spice oil (ESO) was stored in a sample bottle, labelled and kept in the laboratory cupboard until when needed for the experiment.

Insect Bioassay

Determination of repellency effect of the edible essential oil treatment on paddy rice

Repellency of the edible essential oils to adult *S. oryzae* was determined using the Petri dish chamber test as described by Sighamony *et al*. (1984) on each of the paddy rice. The test arena consists of a 9 cm diameter Whatman No.1 filter paper cut into two halves. One half of the filter paper was held in place with the other half with a cello tape, thus forming a whole unit. Four concentrations of the different edible essential oils (EEO) were prepared by dissolving 0.25, 0.5, 0.75 and 1.0 mg each in 2 ml analytical grade acetone. Each concentration was applied to one half of the filter paper disc as uniformly as possible by means of the pipette. The other half of the filter paper was left untreated. In the control chambers, half of the paper was treated with 2 ml pure analytical grade acetone and the other half left untreated. Before the introduction of test insects into the Petri dishes, the acetone used as the carrier was allowed to evaporate completely. Thereafter, 30 unsexed adult *S. oryzae* (2 - 3 days old) were released at the center of the Petri dish and then covered with the lid. The number of insects present in treated and untreated discs was recorded after 30 minutes. The experiment was laid down in a complete randomized designed (CRD) and replicated three times.

Determination of toxicity effect of edible essential oil on *S. oryzae*

Toxicity of edible essential oils against adult S. *oryzae* was carried out using 0.25, 0.5, 0.75 and 1.0 mg of the oils dissolved separately in 2 ml of analytical grade acetone and treated on 20 g of one variety of paddy rice in a 50 ml glass jar with a lid. A glass rod was used to stir the oil on the paddy rice in order to ensure adequate coating of seeds with the oil; stirring was stopped when the acetone used as the carrier have completely evaporated. The control was treated with the same amount and weight of seeds treated with 2 ml analytical grade acetone alone. This was stirred until complete evaporation of the acetone. Thereafter, 30 adults (2 - 3 days old) *S. oryzae* were introduced into the paddy rice by means of a pooter. Adult mortality was taken 24 h after treatment. The adults were counted as dead if it did not respond to probing with a fine brush bristle (Su, 1976). The experiment was laid down in a complete randomized designed (CRD) and replicated three times.

Determination of toxicity effect of edible essential oil on *S. oryzae*

Toxicity of edible essential oils against adult S. *oryzae* was carried out using 0.25, 0.5, 0.75 and 1.0 mg of the oils dissolved separately in 2 ml of analytical grade acetone and treated on 20 g of one variety of paddy rice in a 50 ml glass jar with a lid. A glass rod was used to stir the oil on the paddy rice in order to ensure adequate coating of seeds with the oil; stirring was stopped when the acetone used as the carrier have completely evaporated. The control was treated with the same amount and weight of seeds treated with 2 ml analytical grade acetone alone. This was stirred until complete evaporation of the acetone. Thereafter, 30 adults (2 - 3 days old) *S. oryzae* were introduced into the paddy rice by means of a pooter. Adult mortality was taken 24 h after treatment. The adults were counted as dead if it did not respond to probing with a fine brush bristle (Su, 1976). The experiment was laid down in a complete randomized designed (CRD) and replicated three times.

Data Collection and Analysis

Repellency effect of edible essential oil

The number of adults repelled from the treated half disc of Whatman No. 1 filter paper 9 cm in the Petri dish was recorded and calculated according to McDonald *et al.* (1970) as follows:

$$\text{Percent Repellency (PR)} = \frac{Nc - Nt}{Nc + Nt} \times 100$$

Where:

Nt = number of insects present on the treated half disc

Nc = Number of insects present on the untreated half disc

The percentage class of repulsion (CR) was classified according to McDonald *et al.* (1970) as follows:

0 > 0.01 = 0

0.1 to 20 = I

20.1 to 40 = II

40.1 to 60 = III

60.1 to 80 = IV

80.1 to 100 = V

Toxicity effect of edible essential oil

Probit analysis was used to calculate the lethal concentration (LC_{50}) of the toxicity effects of the edible essential oil on treated adult *S. oryzae*; while fiducial limit was used to determine the significant differences between the oil treatments.

Statistical Analysis

All data collected were analyzed in one-way and two-way ANOVA. Differences between mean responses were compared using the Least Significant Difference (LSD) statistic ($P \leq 0.05$). All data with zeros were transformed to square root method using $\sqrt{x} + 0.5$. All percentage data were transformed before analysis. Data analysis was carried out with STAR® (2013) analytical package.

RESULTS

Effect of concentration rates on the mean percentage number of adult *S. oryzae* repelled by the three edible essential oils infesting paddy rice.

The edible essential oils extracted from clove, *S. aromaticum*, *P. guineense* and *Z. officinale* were used to determine the repellent effect of the oils on the rice weevil, *S. oryzae* as shown on Table 1.a below. The results of the observation showed that the three edible essential oils significantly ($P \leq 0.05$) repelled the rice weevil at higher dosage rates when compared to lower dosage rates.

Extracts from clove oil at the dosage rate of 1.00 mg repelled higher number of adult *S. oryzae* (77.80) significantly ($P \leq 0.05$) more than all the dosage rates, 0.75 (71.11), 0.50 (63.33) and 0.25 (63.33) mg and the control (53.33) while 0.25 mg and the control were not significantly different from each other ($P \geq 0.05$). Higher number of adult *S. oryzae* was repelled more in treatment with 1.00 mg (85.56) of WABP but this was not significantly different ($P \geq 0.05$) from treatment with 0.75 mg (84.44); and were significantly different ($P \leq 0.05$) from treatments with 0.50 (61.11) and 0.25 mg (41.11) which were all significantly different ($P \leq 0.05$) from the control (33.33). The repellency effect of treatment with ginger oil showed that, all the oil treatments were significantly different ($P \leq 0.05$) from each other with treatment with 1.00 mg (92.22), 0.75 mg (84.44), 0.50 mg (74.45), 0.25 mg (61.11) and the control (33.33), respectively (Table 1.3a).

Table 1; a Effect of concentration rates on the mean percentage number of adult *S. oryzae* repelled by three edible essential oils infesting paddy rice

Dosage (mg/30 cm^2)	Edible Essential Oil Type			
	Clove	WABP*	Ginger	Mean
0.25	53.33^{+b}	41.11^{b}	61.11^{b}	51.85
0.50	63.33^{b}	61.11^{c}	74.45^{c}	66.30
0.75	71.11^{b}	84.44^{d}	84.44^{d}	80.00
1.00	77.78^{c}	85.56^{d}	92.22^{e}	85.19
0.00 (Control)	32.29^{a}	33.33^{a}	33.33^{a}	32.98
Mean	59.57	61.11	69.11	

Means with the same letter in the column are not significantly different at 5% level of probability using Least Significant Difference (LSD) Test ($P \leq 0.05$).
\+ = Repellence percentages of three replicates
*WABP = West African black pepper

Interaction effect of three edible essential oils on mean percentage numbers of adult *S. oryzae* repelled on paddy rice varieties

Repellency effect of all the three edible essential oils (EEO) were statistically and significantly effective ($P \leq 0.05$) from each other (Table 1b). The highest repellency effect was recorded with the use of ginger oil with 92.22% repellency which was significantly different from oil treatment with WABP (85.56%) and that of clove (77.78%). The effect of treatment with WABP oil was also significantly different ($P \leq 0.05$) when compared with the effect of clove oil.

Table 1;b Interaction effect of three edible essential oils on mean percentage numbers of adult *S. oryzae* (L.) repelled on paddy rice varieties

Edible Essential Oil Type	Treatment Means (mg/30 cm^2)
Clove	77.78^{c}
WABP	85.56^{b}
Ginger	92.22a

Means with the same letter in the column are not significantly different at 5% level of probability using Least Significant Difference (LSD) Test ($P \leq 0.05$).

Classification of Repellency of the Three Edible Essential Oils against *S. oryzae* Infesting Paddy Rice

Table 1.c showed the repellency classification of the three edible essential oils on adult *S. oryzae*. The results showed that clove oil at the dosage rate of 1.00, 0.75 and 0.50 mg elicited Class IV (77.78, 71.11, 63.33) repellency, respectively; while WABP and ginger oil at the dosage rate of 1.0 mg were classified as Class V (85.56 and 92.22), respectively. All the three oils clove (53.33), WABP (61.11) and ginger (41.11) recorded Class III when used at the dosage rate of 0.25 mg. However, ginger at the rate of 0.50 mg was Class III (61.11). WABP (74.45) on the other hand was classified as Class IV at the dosage rate of 0.50 mg. All the control treatments were classified as Class II.

Table 1;c Classification of Repellent Action of the Three Edible Essential Oils against *S. oryzae* infesting Paddy Rice

Dosage (mg/30 cm^2)	Edible Essential Oil Type					
	Clove		**WABP***		**Ginger**	
	Mean % Repellency	[a] Repellency Class	Mean % Repellency	Repellency Class	Mean % Repellency	Repellency Class
0 (Control)	32.29	II	33.33	II	33.33	II
0.25	53.33	III	61.11	III	41.11	III
0.50	63.33	IV	74.45	IV	61.11	III
0.75	71.11	IV	84.44	V	84.44	V
1.00	77.78	IV	85.56	V	92.22	V

*WABP = West African black pepper

[a] Repellency Class: Class II = 20.1 – 40%; Class III = 40.1 – 60%; Class IV = 60.1 – 80%; Class V = 80.1 – 100%.

Contact Toxicity Effect of Three Edible Essential Oils on the Adult *S. oryzae* Infesting Paddy Rice

The contact effect of clove, WABP, and ginger edible essential oils against the adult rice weevil, *S. oryzae* is presented on Table 2.a. The results showed that essential oil from clove was the most toxic at a concentration ratio of LC_{50} of 0.385 followed by WABP oil at LC_{50} 0.581. Lowest mortality of the adult *S. oryzae* was recorded in ginger at LC_{50} 0.658 signifying less contact toxicity. The Fiducial confidence level limit between the three edible essential oils were 0.118 - 0.564, 0.381 - 0 703, and 0.491 - 0.992, respectively for clove, WABP and ginger. The regression analysis in Figures 1, 2, and 3 inveterate that there is an increase in toxicity effect with an increase in concentration among the three oils of clove, WABP and ginger and the r^2 regression analysis showed that the interaction between the concentrations and the use of the EEOs as contact toxicity on adult *S. oryzae* were significant for clove, 0.873; WABP, 0.991 and ginger, 0.993, respectively.

Table 2.a Toxicity effects of Three Edible Essential Oils on *S. oryzae* infesting Rice Paddy in Storage

Edible Essential Oil Plant	Plant Part	LC_{50} (mg/5 g seed)	95% Fiducial Limit	Slope values	R^2 values
Clove	Seed	0.385	0.118 – 0.564	1.114	0.873
WABP*	Seed	0.531	0.381 – 0.703	1.693	0.991
Ginger	Rhizome	0.658	0.491 – 0.992	1.619	0.993

*WABP = West African black pepper

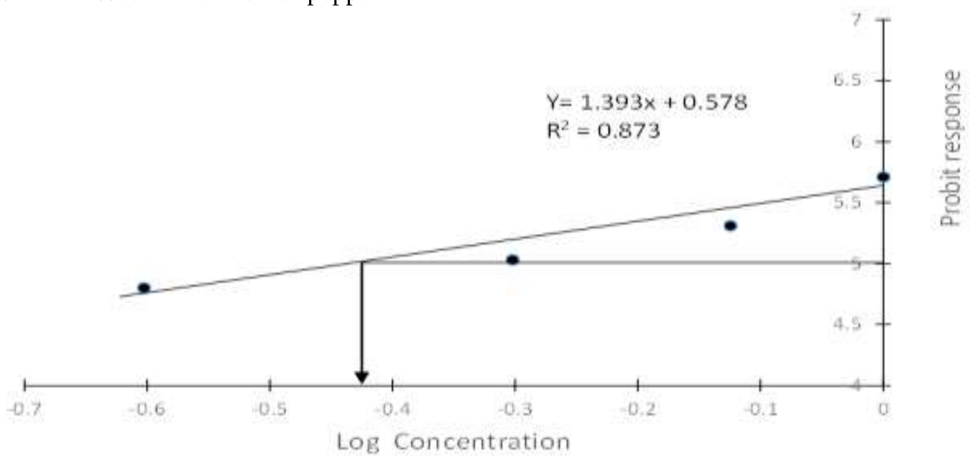

Figure 1: Toxicity Effect of Clove Edible Essential Oil (Log. Conc. -0.415, LC_{50} = 0.385 mg); Fiducial Limits (Confidence Interval): 0.118 - 0.564 mg/5 g seed.

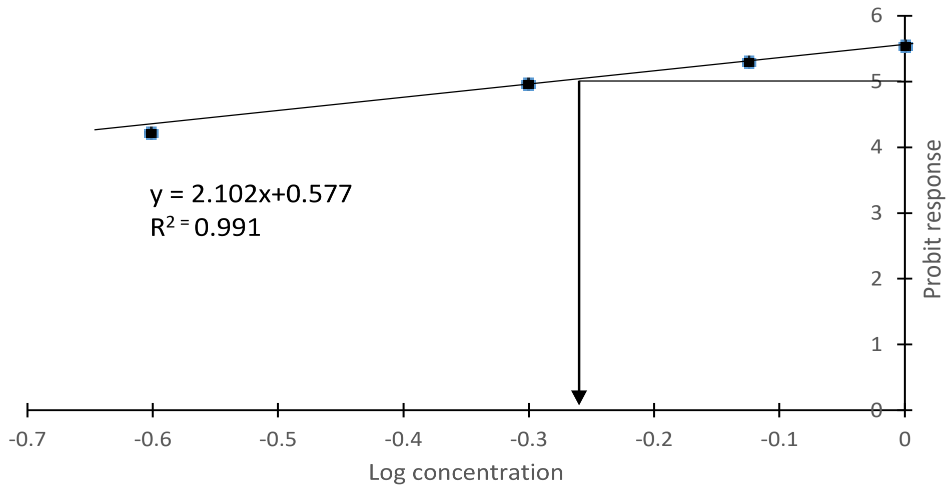

Figure 2: Toxicity Effect of WABP Edible Essential Oil (Log. Conc. -0.275, LC_{50} = 0.581 mg); Fiducial Limits (Confidence Interval): 0.381 - 0.703 mg/5 g seed.

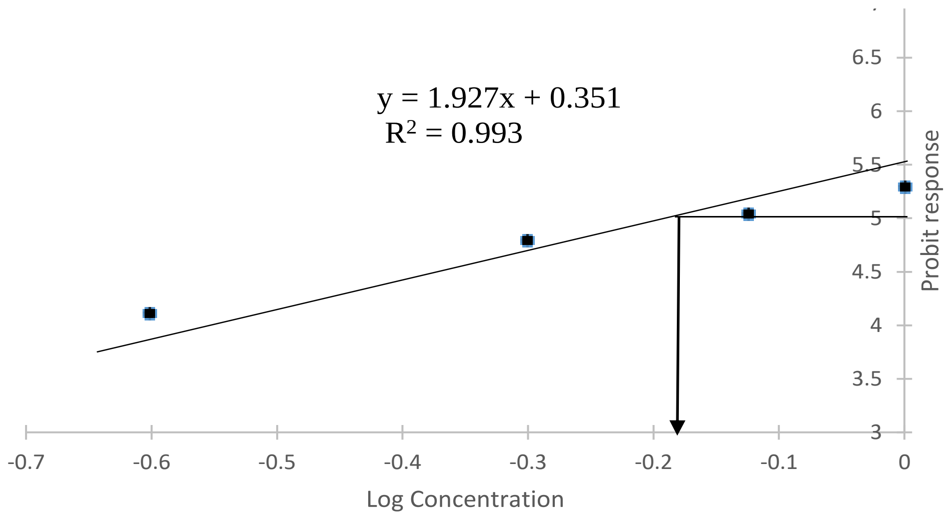

Figure 3: Toxicity Effect of Ginger Edible Essential Oil (Log. Conc. -0.182, LC_{50} = 0.658 mg); Fiducial Limits (Confidence Interval): 0.491 - 0.992 mg/5 g seed.

DISCUSSION

Repellency effect of three edible essential oil extracted from clove, WABP and ginger on adult *S. oryzae* infesting paddy rice varieties

Edible essential oil extracted from clove, WABP and ginger were used to repel adult *S. oryzae* on paddy rice variety (Tables 1.3a, 1.3b and 1.3c) showed varying degrees of repellency by these oils. In an earlier report, Ajayi and Lale (2000-2001) reported that oils extracted from clove, WABP and ginger caused repellency classes of II – V on adult *Callosobruchus maculatus* at concentrations of 50 – 250 mg/30 cm^2. As observed in this study, repellency classes of III – V was achieved at concentrations of 0.25 – 1.00 mg/30 cm^2 however at lower dosage rates and on different stored produce and stored pests.

The results are also in agreement with the report of Asawalam (2006) who reported that *P. guineense* oil evoked repellency class V on maize weevil; Bandara and Senevirathne (2022) who reported that clove oil evoked class V on the rice weevil, *S. oryzae* and Suthisut *et al*. (2011) had also showed that ginger oil evoked class V on the maize weevil, *S. zeamais* at higher dosage rates.As found out in this study for repellency, ginger oil seems to have contained higher repulsion ability than clove and WABP, Table 4,3b; this however, depends on the chemical constituents inherent in the oil which might contain irritant and foul-smelling chemicals that have the ability to strongly repel stored product insect pests (Al-Harbi *et al*., 2021; Patiño-Bayona *et al*., 2021).

Toxicity effect of three edible essential oil extracted from clove, WABP and ginger on adult *S. oryzae* infesting paddy rice varieties

The results in Table 2.a, Figures 1, 2 and 3, showed increase in weevil mortality after 24 hours with increase in lethal concentrations of the treatment applied. Clove EEO caused high mortality of adult weevil (LC_{50} = 0.358 mg/5 g seed), followed by WABP (LC_{50} =0.531 mg/5 g seed), while the lowest mortality was recorded in ginger oil (LC_{50} = 0.685 mg/5 g seed). In toxicity studies involving products obtained from other plant species, it was reported that insect mortality was due to the biologically active components of the plant products. The edible essential oils from clove, WABP and ginger were able to cause mortality of adult *S. oryzae* at very low lethal concentrations (LC_{50}). The results obtained from this study is in agreement with results of Ajayi and Lale (2000-2001) who reported the toxicity of clove, WABP and ginger oils on *C. maculatus* at very low LC_{50}.

The propensity of the edible essential oils to cause mortality to the adult *S. oryzae* could be due to the constituents in the plant product oils. The oil obtained from clove oil has been reported to contain eugenol, a sesquiterpene and β-caryophyllene, and α-humulene (Haro-González *et al*., 2021); *Piper* species have been reported to contain pipercide, dihydropipercide and guineensine (Gutiérrez *et al*., 2013) and ginger contains a mixture of chemical substatnces which include zingiberene, methylheptone, nonylaldehyde and linalool (Rahmani *et al*., 2014). Although, this aspect was not investigated in the present study, it is probable that the insecticidal properties of these spice oils may be attributable to these biologically active components. Clove oil has however been reported to be more toxic to adults of *C. maculatus* than oils extracted from WABP and ginger oil (Ajayi and Lale, 2000-2001). This is in consonance with the results obtained from the present study. The eugenol contained in clove appears to contain higher insecticidal potency than the active components of WABP or ginger oil since the former was more toxic than the latter.

This study provided evidence that the essential oils made from *S. aromatic*, *P. guineense* and *Z. officinale* were toxic to rice weevil. As a result, they might be employed as botanical entomocides in place of synthetic chemical insecticides to lessen the risky side effects associated with the use of chemical insecticides that can caused environmental health hazards.

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SCREENING ORANGE- AND YELLOW- FLESHED SWEET POTATO GENOTYPES FOR HIGH STORAGE ROOT YIELD AND DRY MATTER CONTENT TRAITS PREFERRED BY INDUSTRIALISTS

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ABSTRACT

A study was carried out on 40 sweet potato genotypes plus two Check local varieties to select sweet potato genotypes with high storage root yield, high dry matter content and high total carotene using a randomized complete block design with three replications at the Western experimental field of NRCRI, Umudike .The planting materials were healthy four (4) node seed vine from the terminal portion of healthy sweet potato mother plants. Each genotype was planted on a 9m^2 plot at a spacing of 100cm between ridges and 30cm between plants on the crest of the ridge. Data collected were on: total number of storage roots, number of large roots, total fresh root weight, weight of large roots. These Data were analyzed with ANOVA and means were separated using Standard error of different means. Storage root dry matter content was determined by oven drying of 100g of fresh sample at 80^{0}C for 48 hours. Results indicated that the dry matter content of the storage roots of the sweet potato genotypes evaluated ranged from 27.7% to as high as 41.2% with mean of 35.2%. However, the Orange fleshed genotypes PG17362-N1 with 38.3%, PGA16021-39 with 36.7%, NAN with 36.3%, NRSP/2019/490 (Smiles) with 34.2%, and NRSP/2019/580 with 32.2%. had dry matter content higher than the reference variety UMUSPO/3 and UMUSPO/4 with both dry matter content of 29.9%, respectively: There may be a challenge combining high dry matter and high beta-carotene. However, with recurrent selection, it is possible to accumulate favourable genes together, so that progress can be made over time.

Keywords: *High dry matter, orange fleshed and carotene*

INTRODUCTION

Sweet potato is an important carbohydrate food, feed and vegetable crop for people in Nigeria. The storage roots of sweet potato which are rich in carbohydrate can be pounded as fufu and its leaves which is rich in minerals and proteins could be used as vegetable for human consumption. Orange fleshed sweet potato varieties are rich in Beta-carotene, a precursor of vitamin A, while Purple-fleshed sweet potato varieties contain anthocyanin, which contain anti-oxidant properties that reduces the aging of cells (Lebot, 2009). Vitamin A deficiency is a serious health problem that results in blindness, weakness and death especially in children below 5 years. Vitamin A boost immunity and is good for pregnant women and lactating mothers. Gurmu et al., (2014) reported that orange fleshed Sweet potato is widely adaptable from the rainforest to the savanna region and generates large amounts of carbohydrate food per unit area within short period of 3.5 to 4 months after planting, giving it an advantage over major root and tuber crop as observed by Mwanga et al (2011). The Storage roots of orange fleshed sweet potato could be boiled, baked, roasted, fried and included in a variety of dishes. The storage roots can also be dried and pulverized to make flour for formulation of bakery products.

Farmers, Marketers and Food processors depend on consumers' preferred traits. Consumer are more attracted to white/cream colour due to the beauty and consistence when frying or boiling. This is related to high dry matter which constitute high carbohydrate. Most sweet potato landraces use as staple food have white/cream flesh colour with dry matter contents which range from 30-to 37% (Rukundo et al., (2013), while dessert types of orange flesh sweet potato have dry matter ranging from 17.7 to 26.3 % (Mcharo & La-Bonte, 2007). Carbohydrate is the most important constituent of dry matter in sweetpotato which make up to 80-90% of the storage root weight. This explain the less choice of orange fleshed which constitute high beta-carotene, but with less dry matter (Picha, 1987). Kambale et al., (2019) reported negative correlation between dry matter content and beta-carotene, but significant and positive correlation between beta-carotene and colour chart comparison. The selection of orange fleshed sweet potato cultivars by urban consumers depends on sensory profiles, knowledge, level of promotion of the crop, and previous experiences of consumers on the crop. Cooking method and utilization have critical influence on taste and consumptive quality of the storage roots (Sugri et al., 2012). Fontes et al., (2011) observed that cooking of the sweet potato orange fleshed storage roots leads to changes in physical, sensory and chemical characteristics of the final product. However, low dry matter content of orange flesh types lose their quality (mealiness) because cooking affect the textural characteristics of the storage root. Frying according to Sugri et al., (2012) enhances sensorial characteristics such as texture, flavour, smell, colour, as well as overall palatability of the product.

The average yield of storage roots of the sweet potato crop in farmers field is only 6t/ha. This low yield is attributed to low yielding of varieties and late maturing of local landraces that farmers are cultivating. This low weight can also be attributed to low dry matter content of the storage root. Woolfe (1992) reported that starch constitutes on average 60 to 70% of dry matter content of storage roots of sweet potato. Dry matter content (DMC) has been used extensively as a selection index for traits such as starch content, flour yield, carbohydrate measure, cooking qualities and taste of the genotypes (Woolfe, 1992). Genotypes with high DMC can be good for storage, and could be candidate for industrial utilization and for international trade. Woolfe (1992) in his work on dry matter content reported highly significant positive correlation between dry matter content and starch content while Lebot (2009) indicated that starch is mainly determined by the additive effect of polygenes. As a results of the food and nutritive benefits of orange fleshed sweet potato, various breeding approaches are being used to develop and improve the orange fleshed sweet potato. The objective of this study was to select sweet potato genotypes with high storage root yield, high dry matter content and high total carotene.

MATERIALS AND METHODS

A total of 40 genotypes plus two Check varieties were evaluated in a randomized complete block design with three replications at the Western experimental field of NRCRI, Umudike. Each genotype was planted on a 9m^2 plot at a spacing of 100cm between ridges and 30cm between plants on the crest of the ridge. The planting materials from all the clones are healthy with four (4) nodes seed vine cut from the terminal portion of healthy sweet potato mother plants and were planted on the ridges with at least two nodes of the seed vine stick inside the soil.

The sweet potato crop were kept weed-free until harvest. At harvest the following data were collected: total number of storage roots, number of large roots, total fresh root weight, weight of large roots. Data collected were analyzed with ANOVA and means were separated using Standard error of different means. Storage root dry matter content was determined by oven drying of 100g of fresh sample at 80^{0}C for 48 hours.

RESULTS AND DISCUSSION

Number of storage roots: The result of 42 sweet potato genotypes on: total number of storage roots, number of large roots, total weight of fresh storage roots, fresh weight of large roots and storage root dry matter content are presented in Table 1.

Table 1: Number, weight, flesh colour and dry matter content of the storage roots of orange fleshed genotypes evaluated

Genotypes	Total number of storage roots	Number of large roots	Total fresh weight of storage roots	Fresh weight of large storage roots	Flesh colour of storage roots	% Dry matter of storage roots
CEMSA 74-228	40	21	12.0	10.4	LY	41.2
PGA14351-4	40	30	8.8	6.8	Y	38.4
PG17362-N1	44	35	8.2	6.2	O	38.3
PGA16021-39	18	12	9.5	7.5	O	36.7
PGA14398-4	72	36	12.0	8.1	Y	36.7
PGA14442-1	34	23	11.2	8.4	YO	36.3
NAN	28	19	12.3	11.2	O	36.3
PGA14008=9	34	26	12.6	12.2	Y	34.5
NRSP/2019/490 (Smiles	54	32	16.6	14.2	O	34.2
NRSP/2012/580	56	31	19.5	15.0	DO	32.2
NWA/OP/239	47	34	12.7	8.0	O	30.2
NWA/OP/23	43	26	14.9	9.6	O	30.2
NRSP/PO3/8	39	24	13.1	6.7	O	30.1
NRSP/PO3/123	39	28	15.1	8.8	O	30.1
TIO-JOE/OP/322	101	83	19.3	15.1	O	30.0
UMUSPO/4 (chk)	15	7	3.2	2.2	D/O	29.9

UMUSPO/3 (chk)	58	39	14.1	11.0	DO	29.9
NRSP/PO3/32	42	36	11.6	7.2	O	29.1
NRSP/PO3/39	61	34	9.6	7.7	DO	29.1
NRSP/2012/68	43	32	10.6	9.2	O	29.1
87/OP/175	61	55	22.1	12.1	DO	29.1
NRSP/2012/066	98	49	23.5	20.6	O	29.0
NRSP/PO3/16	117	89	22.7	17.3	O	28.7
NRSP/PO3/136	64	38	13.2	8.8	DO	28.6
NRSP/2012/06	83	66	17.1	9.8	DO	28.6
87/OP/65	62	31	14.7	11.8	LO	28.6
NRSP/PO3/35	44	32	8.9	7.8	Y	28.4
NWA/OP/253	42	36	17.1	11.6	LO	28.3
NRSP/PO3/119	81	52	15.7	12.3	DO	28.3
NRSP/2012/187	68	49	23.3	18.1	O	28.3
NRSP/PO3/18	34	28	7.6	4.5	DO	28.2
NWA/OP/230	38	26	12.1	9.2	O	28.2
NRSP/2012/1068	77	52	18.2	10.2	DO	28.2
NRSP/PO3/85	43	31	11.1	7.1	DO	28.1
NRSP/PO3/051	32	25	10.1	7.3	D/O	28.1
NRSP/PO3/005	31	28	9.6	7.5	D/O	28.1
87/OP/215	52	36	15.1	8.7	DO	28.1
NRSP/PO3/116	46	29	15.3	12.3	DO	28.1
87/OP/195	56	36	16.2	10.8	DO	27.7
NRSP/PO3/062	37	22	8.7	6.2	O	27.6
NRSP/PO3/37	64	43	22.1	16.2	DO	27.2
NRSP/PO3/31	61	48	19.6	14.2	DO	26.0
Mean	52.4	35.9	14.2	10.4	=	30.5
Range	15-117	7-89	3.2-	2.2-20.6	=	26.0-41.2
S.E	7.3	6.1	3.8	3.3	=	=
Prob level	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	=	=

Note: DO = Deep Orange, Y= yellow, LY = light yellow, O = orange, LO = light orange, YO = yellow intermediate orange.

The number of storage roots produced by each of the genotypes varied significantly ($p<0.01$) and ranged from 15 number of roots per plot as produced by UMUSPO/4 to 117 number of storage roots per plot as produced by NRSP/PO3/16. This was followed by TIO-JOE/OP/322 with 101 number of roots per plot with a general mean of 52.4 number of roots per $9m^2$ plot. Total number of storage roots is not a good index for measuring Storage roots for commercial yield. Total number of storage roots indicated the potential yield with which the farmer visually estimate the yield of the sweet potato crop.

The large root is for the commercial roots with marketable attributes. The large roots varied significantly ($p<0.01$) within the sweet potato genotypes and ranged from 7.0 number of storage as produced by UMUSPO/4 to as high as 89 number of storage roots as produced by NRSP/PO3/116, followed by TIO-JOE /OP/322 with 83 number of storage roots per plot with general mean of 35.9 number of storage roots per $9m^2$.

Weight of Storage roots: This is the fresh matter weight of the storage root of the sweet potato genotypes. The fresh storage root yield is weight of fresh matter and water in the storage roots. The total fresh storage root weight varied significantly ($p<0.01$) among the sweet potato genotypes. The least total fresh root weight was 3.2t/ha as was produced by UMUSPO/4 to as heavy as 23.5t/ha as was produced by NRSP/2012/066. This was followed by 23.3t/ha produced by NRSP/2012/187 with general mean of 14.2t/ha. The total fresh root weight was made up of the weight of small roots and weight of large roots. However, the weight of large fresh roots varied significantly ($p<0.01$) among the genotypes and range from 2.2t/ha (UMUSPO/4) to as heavy as 20.6t/ha (NRSP/2012/066) followed by 18.1 as produced by NRSP/2012/187 with general mean of 10.4t/ha. Large storage root are roots for commerce. The orange and Yellow fleshed genotypes that produced large roots with weight heavier than the two Check varieties: UMUSPO/3 and UMUSPO/4 were selected for further advancement. Fifteen sweet potato genotypes out of 42 which represent 37.5% were outstanding in yield performance more than the two check varieties.

Storage root dry Matter Content: Storage root dry matter is the remaining part of the edible root after its water has been completely drained away by heat or dry air. The dry matter content of the storage roots of the sweet potato genotypes evaluated ranged from 27.7% to as high as 41.2% with mean of 35.2%. However, the Orange fleshed genotypes with dry matter content higher than the reference variety; UMUSPO/3 which had dry matter content of 29.9% were: PG17362-N1 with 38.3%, PGA16021-39 with 36.7%, NAN with 36.3%, NRSP/2019/490 (Smiles) with 34.2%, and NRSP/2019/580 with 32.2%. The following white/cream and yellow sweet mpotato genotypes exceeded the dry matter bench mark of 29.9% set by the national check variety UMUSPO/3 and UMUSPO/4. Cemsa 74-228 with 41.2% followed by PGA14351-4 with 38.4%, PGA14398-4 with 36.7%, PGA14442-1 intermediate yellow orange with 36.3%, PGA14008-9 with 34.5% and PGA17362 –N1 with 38.4% (Table 1).

Carbohydrate is the most constituent of dry matter in sweet potato. Mcharo and La Bonte (2007) reported that 80 - 90% exists in form of starch and sugars. According to Woolfe (1992) starch is quantitatively the most important component of sweet potato storage root dry matter content and that it is found in two general forms such as amylose and amylopectin. The ratio of amylose and amylopectin is genetically controlled and differs between genotypes. Woolfe reported that starch constitutes on average 60 to 70% of dry matter content of storage roots of sweetpotato. Dry matter content (DMC) has been used extensively as a selection index for traits such as starch content, flour yield, carbohydrate measure, cooking qualities and taste of the genotypes (Woolfe, 1992). Genotypes with high DMC can be good for storage, and could be candidate for industrial utilization and for international trade. Woolfe (1992) in his work on dry matter content reported highly significant positive correlation between dry matter content and starch content while Lebot (2009) indicated that starch is mainly determined by the additive effect of polygenes. These genotypes could be proposed according to a specific condition under particular location for high dry matter content, and they can be good candidates for industrial purposes. Genotypes with high dry matter content are good sources of starch, so it can contribute for industrial utilization (Scott et al., 2000). Lu and Sheng (1990) observed that raw dry matter content of above 35% is an ideal material that refers to the processing industry. Therefore, breeding for high DMC, should be a focus of plant breeding objectives. Comparing, with other studied traits such as storage root yield and harvest index. Diaz et al (2021) reported of dry matter content of 37.2% and 33% for two South American orange fleshed clones. In this study, the dry matter content of the sweet potato genotypes ranged from 27.7 to 41.2% (Table 1). Various researchers have reported high heritability estimates of 75 - 88% of dry matter content of 64% (Jones *et al* 1986) which indicated high genetic gain for improvement. Nevertheless, there is negative correlation between beta-carotene and dry matter content (and with sugar and starch (Lebot, 2009). There may be a challenge combining these traits in one cultivar. However, with recurrent selection, it is possible to accumulate favourable genes so that progress could be made over time.

Genotypes containing higher levels of β-carotene are more likely to have lower levels of starch and, therefore, lower levels of dry matter (Cervantes-Flores et al 2008). However, with the use of recurrent mass selection, successes have been attained in breeding varieties that combine both traits in that several high dry matter cultivars have been developed that have high levels of beta-carotene (Gruneberg *et al*., 2009). High dry matter of OFSP storage roots have taken on greater importance for export for baby food manufacturing industries. Higher dry matter OFSP are to develop export opportunities.

The dry matter content of 31.0% the genotypes were above 30.0%, which indicated that these genotypes would possess acceptable taste. This is because good sweet potato taste is associated with high dry matter content. Also sweet potato genotypes with high dry matter content would yield high starch and flour for industrial uses such as making of baby foods (Caetano *et al*. 2017).

CONCLUSION

Breeding for high dry matter content in Orange fleshed sweet potato has been one of the breeding objectives and challenge of the breeding programme. Genotypes containing higher levels of β-carotene are more likely to have lower levels of starch and, therefore, lower levels of dry matter. With recurrent selection methods, it is possible to accumulate favourable genes so that progress could be made over time. However, with the use of recurrent mass selection, successes have been attained in breeding varieties that combine both traits in that several high dry matter cultivars have been developed that have high levels of beta-carotene. High dry matter of OFSP storage roots have taken on greater importance for export for baby food manufacturing industries. Higher dry matter OFSP are to develop export opportunities. The dry matter content that ranged from 28 to 30.0% is acceptable to sweetpotato consumers as high dry matter content gives good taste and this has been extended up to 38% to include industrial uses and for export. The genotypes with high dry matter content should be tested in different locations for yield stability for selection of superior genotypes with high dry matter that will be acceptable to the end-users.

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PROCESSING METHODS OF CASSAVA INTO ANIMAL FEED: A REVIEW

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ABSTRACT
The competition for conventional feedstuff between livestock and humans has led to an increase in the cost of livestock and poultry feeds. Therefore, this review has necessitated the search for alternative non-competitive feedstuffs in order to partially replace maize and soybean in animal feeds. Cassava is a tropical crop, and its fodder is rich in crude protein (CP), minerals and vitamins with about 85% of the CP fraction existing as true protein. The cassava root is very high in energy capable of completely or partially replacing maize. Cassava by-products are also high in nutrients and could contribute significantly to the nutritional needs of animals. Specifically, cassava leaves are high in CP (25.10%) with an amino acid composition similar to soybean. However, the use of cassava in animal production is limited by the presence of cyanogenic glucosides (linamarin and lotaustralin) that releases hydrogen cyanide (HCN) known to cause pathophysiological changes in the liver of the animals. Importantly, several processing techniques (peeling, grating, drying, ensiling, boiling, soaking/retting, fermentation and combination of processing methods) are well known to reduce or eliminate the concentrates of cyanogenic glucosides in cassava with great success. It is concluded that processing reduces HCN contents of cassava to a tolerable level for animals. However, combination of different processing methods showed to have reduced HCN better than the use of a single processing method.
Keywords: *Processing techniques, cassava, animal feed, cassava by-products, livestock and poultry*

INTRODUCTION
Cassava production is vital as it is seen as the future of food security in Nigeria (Jiwuba *et al*., 2018); with approximately one billion people currently depending on it as a major carbohydrate source (Ezenwaka *et al*., 2018). Recently cassava annual production has increased by approximately 100 million tonnes since 2000 (Morgan and Choct, 2016), this may be partly due to the high demand for cassava food products and for use in livestock and poultry feeds. FAO (2014) reported a 4.6% cassava output growth in 2013 and 2014, with Nigeria being the world's largest producer. Under tropical conditions, it is the most productive crop in terms of energy yield per unit land area, with a yield of between 25 and 60 tonnes/ha (1 ha ¼ 10,000 m^2) (Garcia and Dale, 1999). These have enhanced the availability of the by-products for animal feeds.
The use of cassava by-products in animal feed is an age-old practice. Traditionally, farmers would sundry the peels in small quantities as a feed resource. Transforming cassava by-products into nutritious animal feed has the potential to partially replace maize in animal feed while reducing environmental pollution and minimising post-harvest losses. This crop-waste by-product could be a valuable feed alternative. This review therefore examines different processing methods used in producing different types of cassava by-products for animal feeding.
Peeling: Almost every technique of cassava processing starts with peeling. Cassava peel contains cyanoglycosides, linamarin and lotausralin, which yield HCN during hydrolysis and have been reported to be toxic to livestock and humans. The parenchyma (pulp) can remove 50 per cent of cyanogenic glycosides by peeling. Bitter varieties of cassava contain about 650 ppm of HCN in the peel and about 310 ppm in the parenchyma (Panghal *et al*., 2019). Varieties of sweet cassava can contain about 200 ppm of HCN in the peel and 38 ppm in the roots (Bayitse *et al*., 2015). Nonetheless, sweet cassava varieties when peeled, may be eaten raw or after boiling, while the bitter varieties need more detoxification for goats and other livestock to consume.
Grating: Grating is size reduction of the roots and therefore increases the surface area for better contact with linamarin and linamarase for easy detoxification. The reduction of the size allows the intracellular linamarin to be

released out of the cell and to react with extracellular linamarase enzyme to yield HCN that can be easily volatilized. The concentration of cyanide in the grated product depends largely on the period during which glucoside and glucosidase interact in an aqueous medium (Tewe, 1992). However, grating provides a larger surface area for fermentation but not sufficient for detoxification; therefore, it is necessary to combine it with other methods to improve the evaporation of HCN.

Drying: Drying is one of the methods used in processing and enhancing the nutritional value of cassava products by reducing cyanide and moisture. Drying is generally accepted as an effective method of processing cassava root, because it results in products that are shelf-stable with moderately low content of cyanide and moisture. Cassava drying or roasting generally comes after peeling, chipping and grating before spreading them thinly out to dry in the sun or in oven. Given advanced drying systems, sun drying is the most commonly used method in Africa's cassava processing and as such, the sun-dried cassava products are the most popular. Sun drying appears to be more effective at reducing cyanide than oven, drying method, because cyanide has contact with linamarase for a longer period when using sun drying (Ngiki *et al*., 2014). Ravindran (1991) claimed that sun drying alone in a cassava sample could eliminate around 90 per cent of the initial cyanide value. Olafadehan (2011) reported a reduction of HCN from 710.98 mg/kg from unprocessed cassava peel meal to 165.36 mg/kg in a sundried cassava peel meal; this explicitly demonstrated the efficacy of sun drying processing method in cassava peels detoxification. Vantsawa and Okenarhe (2014) in a study reported a reduction of HCN from 3.16 mg/100g on freshly harvested cassava leaves to 1.46 mg/100g in a sundried cassava leaves; hence demonstrated the role of sun drying as one of efficient processing methods of detoxifying cassava leaves.

Ensiling: The ensiling process causes the intact glucoside to disintegrate through marked disruption of the cell, decrease in pH of the ensiled medium and intense heat generation. Ensiled cassava by-products are commonly used for feeding ruminants and non-ruminants. Olafadehan (2011) reported a reduction of HCN from 710.98 mg/kg from unprocessed cassava peel meal to 299.21 mg/kg in an ensiled cassava peel meal in 14 days ensiling period. In another study, Loc *et al*. (1997) found that the HCN content of ground whole cassava root was reduced from 109 ppm to 64 ppm after 60 days of ensiling, whereas ensiling the chipped root reduced HCN from 111 ppm to 71 ppm. Similarly, Okah *et al.* (2017) reported that ensiling cassava peel meal reduced the cyanide content to 6.25 ppm of the initial value of 27.30 ppm after an ensiling period of 21 days.

Boiling: Boiling is a high-temperature processing technique that results in the inactivation of heat-sensitive β-glucosidase linamarase and therefore linamarine is not hydrolyzed into cyanohydrin, resulting in a reduction of only up to 50% in cyanide content (Panghal *et al*., 2019). Boiling (heat) enhances immediate evaporation of HCN in cassava by-products. The reduction in cyanogenic glycosides content was related to the boiling time. Jansz and Uluwaduge (1997) reported that boiling cassava reduced about 50-70 per cent of the cyanogens. Boiling cassava leaves was reported to reduce HCN by 75 per cent (Hidayat *et al*., 2002). Vantsawa and Okenarhe (2014) recorded reductions in HCN from 3.16 mg/100 g on freshly harvested cassava leaves to 0.62 mg/100g in dried cassava leaves per boiled and shaded leaves.

Soaking/Retting: Soaking the roots of cassava is usually preceded by fermentation, boiling or drying. Retting, accompanied by sun drying, is used in some parts of Africa as a way of processing cassava roots. This technique of soaking cassava roots in stagnant or slow running water induces tissue splitting and starchy mass extraction. The water softens the cassava root cells, offers a more fermenting medium, and promotes the leaching of cyanogenic glycosides. The approach extracts a large amount of free HCN but has little effect on bound cyanide. Soaking peeled or unpeeled cassava roots is practiced in Nigeria and some other parts of West African countries (Jiwuba *et al*., 2018) to produce *fufu*, *waluwa* and *kanyakaska*. This method reduces HCN for unpeeled cassava roots by about 31.0 percent and cassava roots by 49.9 percent, peeled roots. Olafadehan (2011) reported reduction of HCN from 710.98 mg/kg from unfermented cassava peel meal to 98.10 mg/kg in a retted cassava peel meal.

Fermentation: Traditionally, fermentation has played a dynamic role in the processing of cassava for years. Fermentation increases the abundance and digestibility of nutrients, sensory qualities, shelf life and increases the tolerable amount of anti-nutrients (Panghal *et al*. 2019). Fermentation as a processing technique mainly enhances cassava nutritional values by biosynthesizing vitamins, essential amino acids and proteins, through enhancing protein content and fibre digestibility, as well as enhancing bioavailability of micronutrients and reducing anti-nutritional factors. The importance of fermentation in cassava processing is based on its ability to reduce to relatively insignificant levels the cyanogenic glucosides. Aerobic and anaerobic fermentation of cassava favours linamarin hydrolysis into HCN. Iyayi and Dosel (2000) and Enidiok *et al*. (2008) have reported reduction in cyanide levels by up to 80 percent and 41 percent during fermentation processes respectively. Many lactic acid bacteria and yeast have linamarase activity and are known to contribute significantly to the breakdown of cyanogenic glycoside during cassava fermentation (Kimaryo *et al*., 2000). The concentration of cyanide between 2–3 ppm completely inhibits the growth of other microorganisms like *Escherchia coli*, and this resistance property favours the growth of lactic acid bacteria for fermented cassava (Kobawila *et al*., 2005). During lactic acid fermentation of cassava roots, a drop in pH is observed and this is the result of the production of organic acids by lactic acid bacteria (Kobawila *et al*., 2005). Such microorganisms are able to use the cyanogens and their degradation products, thereby removing their substrate from these harmful substances and making the substrate safe. Linamarase enzymes work on cyanogenic glycosides during the fermentation process and are accountable for cassava products being detoxified. Fresh cassava root contains approximately 400 to 440 mg / kg HCN that could be reduced to 84 mg / kg by wet fermentation and 14 mg / kg by solid-state fermentation (Muzanila *et al*., 2000) and 15 or 8 g / kg by fermentation (Udedibie *et al*., 2004).

Lambri *et al*. (2013) documented the effect on toxin reduction by the type of microorganisms used in fermentation. The selected micro-organisms with grated cassava roots were inoculated for 48hrs. *S. Cerevisiae* was found to be more effective in reducing HCN by 65.9 per cent compared to *L. plantarumm* V22 (50.9 per cent), *O. Oeni* (55.1%) and mixed cultivation (34.2%). The use of nutrients by microorganisms or leaching out is responsible for increasing nutrient content. The type and state of the fermentation depends on the vitamin, protein, amino acid, and mineral levels after fermentation. The other result of fermentation is the removal of anti-nutrients that are found in cassava, i.e. phytates and tannins. Gidamis *et al*. (1993) reported that fermentation in the solid state reduces 89.6 per cent of the total cassava roots cyanogens. Ernesto *et al.* (2002) recorded that retention of cyanide in heap fermentation was found to be 12.5–16.5 per cent.

Combination of processing methods: From the above discussion, it is quite clear that a single method is not self-sufficient to reduce the cassava toxicity up to safe limits, so different methods can be used in conjugation to have cumulative impact. Oke (1994) confirmed that soaking cassava roots prior to sun drying increases the efficiency of detoxification (97.8–98.7%). Retting fresh cassava roots for 3 days then drying for 3 days give the result of 85.9% cyanide reduction. On the other side, crushing roots before sun-drying allow 96–99% of total cyanogens to be removed. This is explained by the fact that crushing damages the plant cells and thus linamarase enzyme comes in direct contact with linamarin. Therefore, sun-drying decreases cyanohydrin and free cyanide (Heuberger, 2005). Soaking and fermenting cassava roots for 3 days allow a decrease of 5.7% of total cyanide content (Westby and Choo 1994). Oke (1994) stated that grating and peeling cassava prior to fermentation, then sun-drying or oven drying with slight heat can result in a product free from cyanogens for any cassava variety. Amoa-Awua *et al.* (1996) reported that sun drying for 6hrs followed by fermentation for 2 days results in 22% less cyanogens. Drying of superficially peeled cassava roots, heap fermentation, and incubating for 3 days, then grinding, sun-drying, and powdering to produce flour after removing of fungal mycelium give a high loss of cyanogens. Grating, fermentation, wetting, drying, and steaming may allow only 2% of cyanogens retained.

CONCLUSION

This review found that cassava roots could be processed to animal feed by different processing methods. This review also showed that cassava roots contain HCN that limits their use in animal feed. It is strongly suggested that HCN content of cassava roots be reduced to a tolerable threshold before use as animal feed. Evidences exist that processing cassava roots reduces the HCN contents. However, combination of different processing methods showed to reduce HCN better than the use of a singular processing method.

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PROXIMATE ANALYSIS OF ELITE CASSAVA GENOTYPE GROWN IN UMUDIKE SOUTH EASTERN NIGERIA

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ABSTRACT
The world today is face with high demand of food due to increase in population and risk from climatic change. There is therefore need to develop plant varieties with high yield advantage that can withstand the advert environmental condition. The aim of this study is to select genotypes with good proximate nutrient qualities among the elite cassava genotypes. Twenty four cassava clones were selected from biotic/abiotic stress tolerance breeding population of the cassava programme of National Root Crops Research Institute (NRCRI), Umudike. The clones were obtained through hybridization and then raised from true seeds in 2015. Four check varieties namely; NR 03/0155, NR03/0211, NR 01/0004 and CR 36-5 were also added to the planting materials. The trial was set up as a Randomized Complete Block Design (RCBD) with three replications in each location. Yield and associated traits were evaluated at harvest. Fresh root weight in kg/plot and its related components were determined at harvest (12 MAP) from the ten inner plants of each plot using quantitative methods.. The data analysis was done using GENSTAT 11 program and Analysis of Variance (ANOVA) for all the traits evaluated. Correlation was done to estimate relationships existing among the traits measured. The result showed that there is significant (P<0.05) difference among the genotypes for all the traits. The findings of the study showed that there were variations in the performances of the genotypes across all the traits evaluated with the best ranking (45.36% of dry matter contents, 27.70% of starch content and ranking index of 9.60) genotype as CR14B-180 and the worst ranking (30.53% of dry matter content, 16.41% of starch content, and ranking index of 4.31) genotype as COB 159-5-4. The best genotype showed good attribute and acceptable range for the traits evaluated.
Keywords: *Proximate, elite cassava, hybridization, genotypes.*

INTRODUCTION
Cassava is described as very important staple crop and the bread of the tropics (Abah, *et al.*, 2022) and an important food security crop in the developing world and a major source of food calories. Starchy tuberous roots of cassava provide food for people in sub-Saharan Africa and Latin America. Cassava is grown mostly by small-holder farmers as an important food and as a cash crop with the average fresh tuber yield under traditional farming practices in sub-Saharan Africa ranges between 8 and10 tons per hectare while the potential yield capacity could be as high as 40 to 60 tons per hectare. The production increases in cassava results not only from surface area expansion of cassava production, but also from productivity increases from genetic research and better agronomic practices which have boosted yields over the years (Nweke *et al.*, 2001).
Economic value for cassava products is largely dependent on the dry matter content (DMC). This is the potential of the crop that reflects the true biological and economic yield. High dry matter content and starch is the main characteristic trait preferred by consumers and processors of cassava. For instance, in sub-Sahara Africa, small-scale farmers preferred cassava varieties that have high dry matter content and starch. The dry matter content in cassava is however influenced by factors such as the age of the plant, crop season, location and light use efficiency. Storage root (DMC**)**) trait in cassava is a component of storage root yield, a complex quantitative inherited trait and it reflects the proportion of useable fresh root yield (Kawano *et al*., 1987). Dry matter content (DMC) is commonly measured using either specific gravity through suspension of a root sample in water and air, or the oven-drying method, which has been the most widely used method. This is where a representative root sample is weighed and then oven dried to constant weight (Fukuda *et al.*, 2010). The oven-drying method is tedious when working with a large number of samples. Likewise, it is difficult to implement this approach where the source of

electricity is unreliable. Both oven-drying and specific gravity method could be substituted by NIRS, which has been shown to predict dry matter content with a high degree of accuracy (Belalcazar *et al*., 2016).

Cassava starch has a high potential used both in industry and for human consumption. The unique properties of cassava starch suggest its use even for specialty markets such as adhesives, baby foods, non-allergenic products and food for hospitalized persons (Moorthy, 1994; Masumbu, 2002). Starch is a valuable ingredient for the food industry, being widely used as a thickener, gelling, bulking and water retention agents. Cassava starch is used directly in different ways or as a raw material for further processing in the production of paper, textiles, as monosodium glutamate (MSG), and as an important flavoring agent in Asian cooking (FAO, 2011; IITA, 2001). Apart from culinary requirements, cassava starch can find application in various industries such as pharmaceuticals, cosmetics, biopolymers, textile, and biofuels (Nassar, 2000). Native and modified starches can be used to influence physical properties of many foods like gelling, thickening, adhesion, moisture retention, stabilizing, texturizing, and anti-stalling applications. Starch and its derived products are important in the paper, pharmaceutical, wood, packaging and textile industries, as well as in ethanol and alcohol production, battery making, and in the production of explosives like matches (Moorthy, 1994**).**

In respect of the importance of cassava to the world, it is face with many challenges demand due to the increase in the population and climatic threat from the environment, there is therefore the need to develop varieties that have high yield performance and high nutrient qualities. This study is therefore carried out to select genotypes with good proximate nutrient qualities among the elite cassava genotypes.

MATERIALS AND METHODS

Source of planting materials

Twenty four cassava clones were selected from biotic/abiotic stress tolerance breeding population of the cassava programme of NRCRI, Umudike. The clones were obtained through hybridization and then raised from true seeds in 2015 and the clonal trial was established in 2016/2017 planting season. Four check varieties namely; NR 03/0155, NR03/0211, NR 01/0004 and CR 36-5 were also added to the planting materials.

Site/location of the experiment

The trial was conducted in National Root Crop Research Institute (NRCRI) Headquarters at Umudike Abia State Nigeria. Umudike lies between latitude 05^{0} 29'N, longitude 07^{0} 33'E and altitude 122m above sea level. It is in the rain forest zone characterized by acidic ultisol soils with annual rainfall range of about 1800m-2500mm and temperature range of 22^{o} C-33^{o} C.

Experimental design

The trial was set up as a Randomized Complete Block Design (RCBD) with three replications in each location. Plot size of 20m^2(4m x 5m dimension i.e. 4 rows by 5 plants) was used with planting distance of 1m x 1m inter and intra row spacing giving a total plant population of 10,000 plants/ha.

Agronomic practices

The trial was carried out in two planting seasons, that is, 2016/2017 and 2017/2018 seasons. Field establishment for the first season was done in the month of July 2016 for all the four locations while the second year planting across the locations was carried out in August 2017. The land was cleared, ploughed, harrowed and ridged using a tractor. Weeding was done at 5 weeks after planting (5WAP), 3 months after planting (3MAP) and 9 months after planting (9MAP). Fertilizer NPK 15:15:15 was applied at 6 weeks after planting (6WAP) at the rate of 400kg/ha.

Data collection

Yield and associated traits were evaluated at harvest. Fresh root weight in kg/plot and its related components were determined at harvest (12 MAP) from the ten inner plants of each plot using quantitative methods. Other field data collected includes; net stand count or number of plants harvested/plot, number of roots per plot, root weight in air, root weight in water and specific gravity.

Determination of Weight in air (Wa), Weight in water (Ww) and Specific gravity

Methodology for specific gravity

The specific gravity was carried out following the standard method of Jaramillo *et al.*, 2005.

- Root sample weighing about 3kg was collected from each genotype and bagged in net sample bags.
- Weighing of sample in air (Wa) was done using a suitable balance
- Weight of the same sample of 3kg was weighed in water (Ww) using sensitive scale.
- Ensuring to use the same container to weigh both in air and in water and that the roots are generally free from soil and other debris.

%Starch and Dry matter content

The starch and dry matter contents were carried out following the standard method of Jaramillo *et al.*, 2005:

Starch and Dry matter content are measured in percentage and calculated by both specific gravity method and oven drying method in laboratory.

Gravimetric method

Determined of **specific gravity:** was done following the methods of Jaramillo *et al.*, 2005. Estimation of dry matter content and starch content in cassava is based on the principle of a linear relationship between specific gravity with dmc and/or starch.

$$Specific\ gravity = \frac{W_a}{W_a - W_w}$$

Where, Wa represents root weight in air and Ww is the root weight in water.

% dmc = 158.3 x specific gravity – 142

% starch = 210.8 x specific gravity – 213.4

Data analysis

Data collected from the field trial were subjected to analysis. The data analysis was done using GENSTAT 11 program and Analysis of Variance (ANOVA) for all the traits evaluated. Correlation was done to estimate relationships existing among the traits measured. Proximate analysis was done in the laboratory to determine starch yield, dry matter content, ash content, crude fibre and cyanide potential.

RESULTS AND DISCUSSION

Figure 1 showed the correlation analysis between the different traits evaluated. The result showed that there is no significant ($p>0.05$) correlations among the traits except between the dry matter content and the starch content with a significant positive correlation coefficient of 0.86. The result of the anova on Table 1 showed the variance component of the different traits measured. The result showed that there is significant ($P<0.05$) difference among the genotypes for cyanide content, crude protein, dry matter content and starch contents of the roots analyzed, but there was no significant difference ($P>0.05$) in the ash content. Table 2 result showed the mean values of the cassava genotypes evaluated which showed that there is significant ($P<0.05$) difference across the genotypes for all the traits. Root weight ranged from 11.03 to 66.33kg with the mean of 33.21kg, cyanide content ranged from 18.52 to 108.10Mg/HCN with the mean of 49.56 Mg/HCN, crude fibre ranged from 0.19 – 2.22% with the mean value of 1.11%, ash value ranged from 0.27 to 1.96 % with the mean value of 1.35%, dry matter content ranged from 23.19 to 45.83% with the mean value of 34.83% and the starch content ranged from 13.23 to 27.80% with the mean value of 21.67%. These results were agreed with the findings of according Nambisan, (2011), that cyanide toxicity of freshly harvested cassava root to humans and animals are classified as follows: non-toxic (less than 50 mg HCN kg^{-1}), moderately toxic (50–100 mg HCN kg^{-1}) and highly toxic (above 100 mg HCN kg^{-1}). Therefore, the result obtained shows that aside CW450-75 and NR030155 which has the values of 105.00 mg HCN kg^{-1} and 108.10 mg HCN kg^{-1} respectively, the genotypes fall within the category of low to moderately toxic type of cassava root genotypes.

Crude fibre is the part of food made up of cellulose and lignin. Food materials with high crude fibre content are low in nutritional value. The result showed low value (0.19 and 0.79) for crude fibre content, with the lowest genotypes as NR 010004 and NR 050046 respectively. These values are also in agreement with the finding of Nambisan (2011). The ash content is an indicative of inorganic constituents (such as minerals). It helps to determine the amount and type of minerals in food; important because the amount of minerals can determine physiochemical properties of foods, as well as retard the growth of microorganisms. (Nambisan (2011). For cassava, the standard generally ranges from 1 to 2% Nambisan (2011). The ash content varied significantly also among the genotypes with the range from 0.27 – 1.96, which fell within the acceptable range.

The ranking index showed that genotypes CR14B-180 ranked as the best genotype across all the traits evaluated, followed by COB 154-5-4 while genotype COB 159-5-4 ranked as the worst genotype.

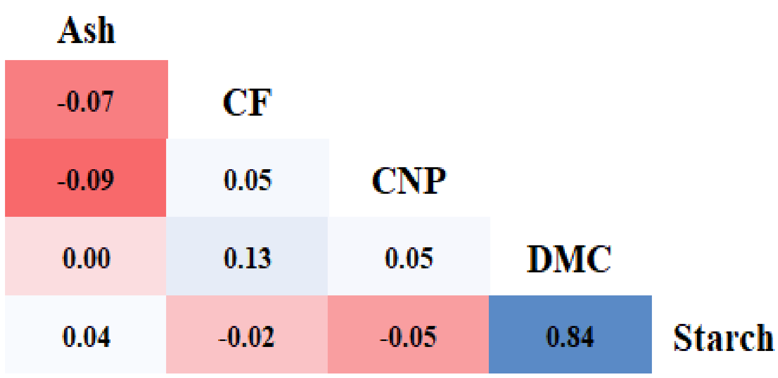

Figure 1: Correlation among the 24 cassava genotypes for the traits evaluated

Table 1: Variance component of the traits

Traits	Genotypic variance	Error variance	F-value
Ash content	111.30	114.90	0.530
Cyanide potential	1281.00	2.49	<0.001
Crude protein content	0.46	0.06	<0.001
Dry matter content	55.55	2.33	<0.001
Starch content	29.98	0.31	<0.001

Table 2: Mean values for the cassava genotypes evaluated

Genotypes	Weight (Kg)	Cynide (Mg/HCN)	Crude Fibre (dw)%	Ash (dw)%	DMC (%)	Starch (%)	Ranking Index	Ranking
COB 154-5-4	42.20	28.09	1.95	1.72	36.00	24.080	8.45	**2**
COB 159-5-11	35.07	35.85	1.76	1.55	35.35	22.995	6.40	**10**
COB 159-5-4	19.47	92.04	1.37	1.41	30.53	16.410	-4.31	**24**
COB 5-17	66.33	75.52	2.05	1.89	25.33	13.365	2.11	**18**
CR 14B-180	51.70	39.94	1.74	1.65	45.36	27.700	9.60	**1**
CR 36-5	36.33	24.87	1.32	1.23	32.88	18.925	7.25	**5**
CR 52A-1	11.03	68.11	1.21	1.15	41.03	24.170	0.26	**21**
CTS 1A-311	23.13	29.76	2.16	1.90	28.33	15.060	4.02	**15**
CW 14B-218	19.80	43.03	1.52	1.24	36.17	22.360	3.75	**17**
CW 444-30	20.53	73.51	1.74	1.42	39.39	24.110	0.34	**20**
CW 450-75	26.60	105.00	1.11	1.03	36.69	21.950	-3.80	**23**
CW 456-17	44.20	39.15	1.85	1.59	34.18	22.285	6.73	**8**
CW 482-3	16.10	40.66	1.22	1.20	41.29	24.965	4.66	**14**
CW 485-15	21.67	35.85	1.06	0.75	37.67	23.990	5.33	**12**
GCO 174-1	56.83	55.19	2.22	1.96	34.15	20.980	5.83	**11**
NR 010004	38.93	36.13	0.19	0.49	39.65	19.135	7.02	**6**
NR 030155	41.93	108.10	1.94	1.34	36.74	22.000	-2.54	**22**
NR 030211	35.33	18.52	1.33	1.69	28.36	24.095	7.99	**3**
NR 050046	39.47	41.22	0.79	0.27	29.33	18.480	4.86	**13**
NR 050067	21.20	30.94	1.71	1.35	39.95	25.990	6.45	**9**
NR 050107	30.67	35.20	1.66	1.25	27.48	14.155	3.92	**16**
TMS 010034	29.37	38.35	1.56	1.03	43.43	27.135	6.96	**7**
TMS 070258	24.33	64.14	1.11	1.77	33.10	22.795	1.11	**19**
TMS 070337	44.83	30.19	1.89	1.61	32.48	20.675	7.60	**4**
Mean	**33.210**	**49.557**	**1.519**	**1.354**	**34.83**	**21.67**		
Min	**11.03**	**18.52**	**0.19**	**0.27**	**23.19**	**13.23**		
Max	**66.33**	**108.10**	**2.22**	**1.96**	**45.83**	**27.80**		
LSD	**3.653***	**4.126*****	**0.645****	**0.189****	**2.101****	**2.510****		

CONCLUSION

The findings of the study showed that there were variations in the performances of the genotypes across all the traits evaluated with the best ranking genotype as CR14B-180 and the lowest ranking genotype as COB 159-5-4. The best genotype showed good attribute and acceptable range for the traits evaluated.

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NUTRIENT COMPOSITION AND ORGANOLEPTIC QUALITY OF "FISH KILISHI" MADE FROM *CLARIAS GARIEPINUS* AND *MORMYRUS RUME*

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ABSTRACT
This study was conducted on Nutrient Composition and Organoleptic Quality of "Fish Kilishi" made from Clarias gariepinus and Mormyrus rume. 10kg live fish was procured from fish sellers in Lafia. The fish sample was divided into 5 Kg each giving the total of 2 samples comprising of T1 (C. gariepinus), T2 (M. rume). The experiment was conducted in a completely randomized design. Organoleptic parameters which included texture, aroma, appearance, taste and general acceptability were assessed. 40 judges were used for the organoleptic assessment. Results of organoleptic assessment of C.gariepinus had the average means of 9.50±0.9, 9.10±.71, 9.50±0.89, 9.90±1.71 and 10.0±0.00 for texture, aroma, appearance, taste and general acceptability respectively. M. rume had the average mean value of 8.00±1.45, 7.80±1.44, 9.00±1.03 and 9.40±0.94 for texture, aroma, appearance, taste and general acceptability respectively. The result by panelist showed that fish kilishi made with C. gariepinus had the highest mean value in texture, aroma, taste and general acceptability. The result of proximate composition of C. gariepinus kilishi had the mean value of 34.13±0.01, 2.29±0.23, 29.45±1.01 and 10.92±0.29 for crude protein, crude fibre, ash, ether extract, moisture content and nitrogen free extract, respectively while M. rume had the mean value of 27.13±1.01, 1.77±0.06, 6.09±0.01, 19.45±0.58, 8.45± 0.52 and 37.11±0.64 for crude protein, crude fibre, ash, ether extract, moisture content and nitrogen free extract respectively. The most preferred product is the fish kilishi made with C. gariepinus and M. rume. This study therefore recommends C. gariepinus for production of fish kilishi. Adequately, filleting the bones, fins and head of the fish should be considered during the preparation of kilishi.
Keywords: *Fish Kilishi, Clarias gariepinus, Mormyrus rume*

INTRODUCTION
Fish is an extremely perishable food with deterioration commencing immediately after harvest (Agbo *et al*., 2002). Prior to death, the enzymes normally get involved in the digestion of ingested food and all microbial activities are controlled. As soon as fish dies, enzymatic action begins on the flesh and alimentary system leading to soft destructive changes. The process is referred to as autolysis. Fish is liable to accelerated physiological, chemical and microbial processes after harvests that invariably lead to deterioration and loss of wholesomeness. It is therefore necessary to come up with some measure of processing such as reduction in moisture content, denaturation of endogenous enzymes and microorganisms or packaging in order to curtail perishability (Vadivel, 2008). Fish consumption provides health benefits to the human population. There is strong evidence that fish, in particular oily fish, lowers the risk of coronary heart disease (CHD) mortality by up to 36 percent due to a combination of EPA and DHA (FAO/WHO 2011). In many low-income countries with water and fisheries resources, fish is important for livelihoods, income and as food for the rural poor people who suffer disproportionately from undernutrition, including micronutrient deficiencies (Thompson and Subasinghe, 2011). Fish is by far the most frequently consumed animal-source and thereby makes a valuable contribution to the diversity of everyday diets, dominated by carbohydrate-rich staples. Fish can therefore be considered an irreplaceable animal-source, providing essential nutrients of high bioavailability which are found in limiting amounts in the diet. These nutrients include animal protein, essential fats, minerals, and vitamins. Small fish, eaten whole or as fish products, e.g. dried fish are particularly rich in calcium and other micronutrients (FAO, 2014).

Kilishi is an Hausa word which refers to slicing, dressing, sun-drying, application of slurry of spices and roasting. Kilishi is a sliced heat-dried seasoned roasted ready-to-eat meat product known to have originated from the Hausa/Fulani speaking people of Northern Nigeria (Odusole and Akinyanju, 2003; Olusola, 2006; Okonko *et al*., 2013). Kilishi has been a convenience travel food across the Sahelian countries and as an export commodity from Nigeria to Saudi Arabia particularly during Hajj. The major problem in the kilishi production has been poor processing and low product technology. This has been tackled with the new improvement done at the University of Benin kilishi research centre. The improvements recorded have enhanced its processing, preservation efficiency, packaging for easy handling, marketing and distribution that will enable kilishi product to be exported to Europe and United States of America through the University of Benin kilishi factory. It is a ready-to-eat convenience meat product (Igene, 2012; Okonko *et al*., 2013). *Clarias gariepinus* was chosen for kilishi preparation because of its availability locally and higher flesh to bone ratio (Achionye-Nzeh and Omoniyi, 2002). It is commonly known as catfish and a valuable fish in Nigeria, which belongs to the family Clariidae. The present study is aimed at utilization and value addition of *Mormyrus spp* and *Clarias gariepinus.*

MATERIALS AND METHODS

Ingredients and Spices for Processing

The defatted groundnut used for slurry formulation were purchased from Lafia Central Market. The principal ingredient were the defatted groundnut dough which were bought from groundnut millers at Lafia, Nasarawa State. Other ingredients used included table salt (sodium chloride), Maggi seasoning and curry powder while spices included dried hot (chilli) pepper (*Capsicum frutescens*), cloves (*Eugenia caryophyllata*), candle wood (*Fagara zanthoxyloides*), ginger (*Zingiber offinale*) and onion (*Allium cepa*).

Preparation of slurry

Slurry was prepared using salt (1.88%), maggi seasoning (0.14%), pepper (4.85%), clove (0.40%), candle wood (0.23%), ginger (2.35%) and onion (11.73%) respectively. The formulations was thick due to high proportion of the principal ingredients (defatted groundnut) used. There was no variation in the spices used.

Fish dressing

The fish samples were washed thoroughly with saline solution and the scales, bones, fins, heads and tail were removed using dissecting set. This enhanced easy filleting of the fish.

Filleting of fish

The samples were exposed to air for 10 minutes so as to reduce the moisture content. With the use of a sharp knife, the samples were cut ventrally from the tail to the head region in fillet form.

First sun drying

The freshly prepared fillets were sun dried to reduce its moisture content.

Infusion of partially dried fillets into slurry

The dried fillets were infused in the prepared formulated slurry containing salt (1.88%), maggi seasoning (0.14%), pepper (4.85%), clove (0.40%), candle wood (0.23%), ginger (2.35%) and onion (11.73%) thoroughly for 10 minutes to ensure absorption of the slurry.

Second sun drying

The infused fillets samples were mounted again in a sun drying raft for 21 hours to undergo second drying. This was to ensure a permanent absorption of the slurry on the fillet.

Roasting

After drying, the dried fillets were roasted at average temperature of 232℃ for seven minutes in the departmental smoking kiln (to ensure blending of ingredients into the dried fish fillets and to enhance taste of the finished products).

Storage of the Products

The fish products were packaged in separate clean air tight containers and were labeled according to their respective samples and it was as such that the plates in which the fish was served for organoleptic assessment. The fish kilishi was stored at room temperature of 28±2℃ for the experimental period.

Sensory (Organoleptic) Evaluation

Samples from the prepared kilishi products were subjected to sensory evaluation immediately to obtain data for the selection of the best out of the two fish species used. The test utilizes the sense of texture, aroma, appearance, taste and general acceptability for quality assessment of dried fish kilishi. The sense of touch was used to assess the texture of the fish, and appearance was used to detect changes in colour and general appearance of the sample. The sense of aroma helped in determining the flavour of good and bad quality of sample. The sense of taste was helpful in determining the palatability and general acceptability of the dried kilishi samples. A 40 membered panel was constituted which consisted of staff and students of the faculty. A 10-point hedonic scale ranging from A (Excellent) = 10; B (Good) = 8; C (Fair) = 6; D (Unsatisfactory) = 4 and E (Unacceptable) = 2 was adopted for each quality parameter. Pencils, tissue paper and water was provided to the judges.

Data Analysis

Data obtained was subjected to One-way Analysis of Variance (ANOVA) in a completely randomized design using SPSS statistical package. Significant mean differences were separated at 5% significance level.

RESULTS AND DISCUSSION

Table 1: Organoleptic assessment of Kilishi made from *Clarias gariepinus* and *Mormyrus rume*

	Organoleptic parameters				
Species	**Texture**	**Aroma**	**Appearance**	**Taste**	**General acceptability**
Clarias gariepinus	9.50± 0.89^{a}	9.10± 1.71^{a}	9.50± 0.89^{a}	9.90± 1.71^{a}	10.00± 0.00^{a}
Mormyrus rume	8.00±1.45^{b}	7.80±1.44^{b}	9.50±0.89^{a}	9.00±1.03^{b}	9.40±0.94^{a}

Means with different superscript along the column differed significantly at P≤ 0.05

Table 2: Nutrient composition of kilishi made from *Clarias gariepinus* and *Mormyrus rume*

	Nutrient composition (%)					
Species	**Crude protein**	**Crude fibre**	**Ash**	**Ether extract**	**Moisture content**	**Nitrogen free extract**
C. gariepinus	34.13± 0.01^{a}	2.29± 0.23^{a}	5.76±0.69^{b}	29.45±1.01^{a}	10.09± 0.29^{a}	17.45±0.35^{b}
Mormyrus rume	27.13±1.01^{b}	1.77±0.06^{b}	6.09±0.01^{a}	19.45±0.58^{b}	8.45± 0.52^{b}	37.11±0.64^{a}

Means with different superscript along the column differ significantly at P≤ 0.05

The result of the sensory scores of kilishi prepared from *Clarias gariepinus* and *Mormyrus rume* was presented in Table 1 above, which revealed that kilishi made from *Clarias gariepinus* was most preferred in terms of texture, aroma, taste and general acceptability of the product with average mean scores of 9.50±0.89, 9.10±1.71, 9.90±1.71 and 10.00± 0.00, respectively. The preferredness of catfish could be due to its flavour, juiciness and tenderness as reported by Safari *et al.* (2001). The species of the fish had influenced on the panelist decision. According to Moloney (1999), meat texture is an important component of meat tenderness and palatability and it has two major components – the first is the impression of wetness produced by the release of fluids from the meat during the first few chews, while the second is the more sustained juiciness that apparently results from the stimulating effect of fat on the production of saliva and the coating of fat that builds up on the tongue, teeth and other parts of the mouth. Meat juices play a vital role in conveying the overall impression of palatability to the consumer. Principally sources of juiciness as detected by the consumer are the intramuscular lipids and water content. When these two combined, the melted lipid constitutes a broth which when retained in the meat is released upon chewing. Such broth may also stimulate the flow of saliva, and thus improve the meat's apparent juiciness (Hedrick *et al.*, 1994). In kilishi inherent muscle water is of less importance in texture because of its low water activity. However the apparent texture observed would be due to the ability of the kilishi to elicit copious flow of salivary juice to moisten the kilishi.

The proximate composition of *Clarias gariepinus* and *Mormyrus rume* kilishi was presented in Table 2. Catfish kilishi had the highest crude protein mean of 34.13±0.01 %; this differed significantly from the mean protein percent of the *Mormyrus rume* 27.13±1.01 (Table 2). This showed that processing fish as in kilishi production improves the percent protein of the product thus making it nutrient dense. Igene *et al*. (1990) reported a value of 50.02% crude protein for traditional kilishi after roasting. Bello and Tekwata (2015) also reported crude protein between 50.76 to 63.3 for solar tent and sun dried kilishi from bony-tongue (*Heterotis niloticus*). The major part of the protein comes from the groundnut cake which has 55.85% (Badau *et al*., 1997). All other ingredients contributed their quota of protein too. The highest crude fibre content obtained in kilishi from *C .gariepinus* (2.29±0.23) was significantly different from that of *M. rume* kilishi (1.77±0.06). Badau *et al*. (1997) reported crude fibre range of 6.1-25.0% for ingredients used in kilishi production. Though the recipes were constituted from virtually the same ingredients, differences were obtained in the crude fibre values of kilishi products. It can therefore be deduced that the varied rate of absorption and adsorption of the dried raw meat slices in the different spice mixture is responsible for the significant differences observed in the crude fibre content of kilishi produced. The ash content of the kilishi samples ranged from 6.09% in *M. rume* to 5.76% in *C. gariepinus*. The result of ash content is in line with the findings of Bello and Tekwata who reported ash content values of 5.00 to 5.33 for fish kilishi made from *Heterotis niloticus.* The pattern of ash content observed in this study revealed that the ash content is influenced by the fish species. Also, another reason could be because most of the ingredients in the slurry might have lost their mineral contents into the slurry hence, into the fish product and this agrees with the report of Elizabeth (1995) who observed that the ash content of any processed meat would be the content of the muscle tissue in addition to that of ingredients used. The ether extract content obtained in this study was highest 29.45±0.01 in kilishi made from *C. gariepinus* and lowest 19.45±0.58 in kilishi made from *Mormyrus rume.* Similar higher values between 17.34 to 19.20 were reported by Iheagwara and Okonkwo (2016). Generally, the fat content of the kilishi samples were high and this can be attributed from the groundnut cake powder which represent a considerable proportion of the product (Igene *et al*., 1990). The moisture content of the kilishi samples ranged from 8.45% - 10.09% with *C. gariepinus* having the highest moisture content of 10.09%. The reduction in moisture content of *M. rume* is desirable as this can affect the quality of the sample positively in relation to other kilishi sample (Apata *et al*., 2013). Generally, the moisture content of the kilishi samples indicates that the kilishi samples were sufficiently dried to minimize microbial growth though moisture values of 6.92%, 9.87% and 10.00% as observed by Jones *et al*. (2001), Apata *et al*. (2013) and Olusola *et al*. (2012), respectively.

CONCLUSION AND RECOMMENDATIONS

It can be concluded that fish kilishi was highly interested and highly accepted by consumer immediately after roasting. Through, the two samples of fish were accepted by the consumers, but the Clarias kilishi was preferred most.

It is recommended that clarias should be used for kilishi due to their strong and hardy nature. Also, the bones, fins and head of the fish should be removed during the preparation of kilishi.

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ASSESSMENT OF WOMEN INVOLVEMENT IN YAM PROCESSING/VALUE ADDITION IN ENUGU STATE, NIGERIA

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ABSTRACT
The study was conducted in Enugu State to assess the level of women involvement in yam processing/value addition in the area. The study was to identify improved yam technologies used by respondents, assess the level of participation of women in yam processing and determine the effect of socio economic factors on yam processing among women.. The study population constituted all women yam producers and processors in Enugu State, Nigeria and the sampling size of the study was Sixty (60) respondents. Primary data were collected using questionnaire. The most common improved technology used by the respondents was organic manure. The most involved processing activities were yam chips, yam flour and yam flakes. Marital status, household size and education had significant effects on yam processing. It was recommended that women should receive more training so that they can participate effectively in yam management technologies and processing activities.
Keywords: *Women, involvement, yam, processing, value addition*

INTRODUCTION
Yam originated in South East Asia and was brought to West Africa in the 16th century. It is one of the principal tuber crops in the Nigerian economy. Nigeria is the leading world producer accounting for over 65% of world yam annually; producing an average of 38 million metric tons (Odinwa*etal* 2016). Yam is an important source of carbohydrate for many people of the Sub Saharan region especially in the yam zones of West Africa. It is the second most important tuber crop in Africa, after cassava, with production reaching above one third of the level of cassava (FAO, 2002). Yam tuber is essentially a starchy food; its principal nutritional functions being the supply of calories to the body. Even though National Root Crop Research Institute, Umudike (NRCRI) had trained rural women in South East Nigeria on value addition of root and tuber crops, including yam, yet not many women are into yam processing/ value addition. Yam can be processed into starch, yam flour, yam ball, yam chips (Salawu, *etal* 2014). Aerial yam can be processed into high quality bulbifera flour, whole meal bulbifera flour and fufu flour. Industrial processing and utilization of yam includes starch, livestock feed, flour and pounded yam flour, yam balls and yam chips, Traditionally, the processing of yam to pounded yam using pestle and mortar is highly valued but is gradually being replaced in the market with instant-pounded yam flour. Processed yam can be easily stored for a long period of 12 - 18 months (Salawu, *etal* 2014) .Women farmers face more constraints than men even though they are more involved in processing of yam. They have less farm size, poor access to most yam production resources, little access to decision making and poor education. Also cultural barriers affect women in yam production and processing activities in parts of South East Nigeria. (Nahanga 2015). This research was carried out to show case women contribution to processing of yam with the following objectives; identification of yam processing technologies used by the women, assessment of level of participation of women in yam processing and examination of the effect of socioeconomic factors on yam processing in the area.

MATERIALS AND METHODS
The study was conducted in Enugu State, Nigeria. The population of the study constitutes all yam producers. Multi-stage sampling technique was used to select the respondents. Local Government Areas purposely selected for the study for reason of large concentration of yam producers were Animi, Agwu and Nkanu West. Two communities were randomly selected from each of the LGAs. A list of all women yam producers in the selected communities were obtained from the extension agents and community leaders in the area, which formed the sampling frame of the study. From the frame, ten (10) women yam farmers were randomly selected for the study which gave a total of sixty (60) respondents for the study. Data were collected using structured questionnaire

administered to these farmers. Data collected were analyzed with descriptive statistics such as frequency tables, means and percentages and multiple regression analysis.

RESULTS AND DISCUSSION

Table 1; Distribution of the respondents according to the yam technologies used

Types of technologies	Frequency	Percentage	Rank
Inorganic fertilizer	35	58.33	6th
Improved variety	52	86.67	2nd
Pesticide	20	33.33	9th
Herbicide	31	51.67	7th
Organic manure	58	96.67	1st
Minisett	39	65.00	4th
Seed yam	40	66.67	3rd
Ware yam	37	61.67	5th
Value addition	21	35..00	8th

Source: Field Survey, 2021 (Multiple response 333)

Results in table 1 presents the improved yam technologies used by the respondents in the study area. The improved yam technologies used by the respondents in Enugu State in their order of popularity, include: organic manure (96.67%), improved variety (86.67%), yam seed (66.67%), minisett (65.00%), ware yam (61.67%), inorganic fertilizer (58.33%), herbicide (51.67%) value addition (35..00%) and pesticide (33.33%). These results show that the most common improved yam technology used in Enugu State, Nigeria was organic manure . Increased utilization of organic fertilizer could be attributed to the fact that it was cost effective and safe.

Table 2. : Mean rating of the level of involvement of women in yam processing/value addition in Enugu State

Indicators	SA	A	D	SD	Total	Mean	Decision
Yam starch	0 (0)	0(0)	0(0)	60(60)	60	1.00	
Yam flour	41(164)	15(45)	4(8)	0(0)	183	3.05	
Chips	29(116)	21(63)	6(12)	4(4)	195	3.25	
Flakes	24(96)	20(60)	10(20)	6(6)	182	3.03	
Amala	10(40)	18(54)	23(46)	9(9)	149	2.48	
Strips	8(32)	17(51)	28(56)	7(7)	146	2.43	
Bread	5(20)	10(30)	26(52)	19(19)	121	2.02	
Ball (Akara)	8(32)	14(42)	20(40)	18(18)	132	2.20	
Chinchin	0(0)	7(21)	30(60)	23(23)	104	1.73	
Cake	2(8)	6(12)	23(46)	29(29)	95	1.58	
Biscuits	0(0)	0(0)	10(20)	50(50)	70	1.17	
Croquette	0(0)	1(3)	24(48)	35(35)	86	1.43	
Confectionaries	1(4)	1(3)	30(28)	28(32)	67	1.12	
Grand Mean						**2.04**	**Rejected**

Source: Field Survey, 2021. Critical mean score = 2.5.

Table 2 presents the level of involvement of women in yam processing/value addition in the study area. The grand mean of the level of participation of women in yam processing in Enugu State was 2.04 and was rejected because the value was less than the critical mean value of 2.5. Out of thirteen value addition activities considered in the study, only four (yam flour (3.05) yam chips, (3.25) yam flakes (3.03)) had very high participation by the respondents. .Apart from Amala and strips, all other value addition activities received low level of participation among the respondents.

Table 3.8.1: Regression estimate of the effect of socio economic factors on yam processing

Variables	+Linear	Exponential	Semi log	Double log
Constant	14972.380	-0.851	-0.255	1.002
	(0.643)	(-2.602)**	(-3.557)***	(0.001)
Age (X_1)	0.047	0.008	0.003	1.100
	(0.193)	(1.592)	(2.950)***	(3.117)***
Sex (X_2)	8641.798	-0.010	-0.102	55.716
	(0.996)	(-0.675)	(-0.631)	(0.002)
Marital status (X_3)	0.812	-0.035	-0.025	-0.471
	(2.471)**	(-0.341)	(-1.145)	(0.110)
Household Size (X_4)	0.820	0.332	0.013	3.832
	(2.944)***	(3.962)***	(0.682)	(0.901)
Education(X_5)	1.349	0.606	0.160	0.001
	(3.843)***	(6.806)***	(8.214)***	(0.800)^0
Income(X_6)	0.275	-0.053	0.026	0.101
	(1.453)	(-0.544)	(1.242)	(7.111) ***
Farming experience (X_7)	-25673.873	0.490	0.033	-4.501
	(-1.152)	(4.797)***	(1.430)	(-3.303)***
Cooperative membership (X_8)	0.265	-0.014	-0.005	13.313
	(1.686)*	(-0.149)	(-0.237)	(0.220)
Farm size (X_9)	-343.178	-0.132	-0.019	-4.581
	(-1.243)	(-1.425)	(-0.949)	(-0.004)
R^2	**0.645**	**0.771**	**0.580**	**04216**
F- ratio	**10.084*** **	**8.224*** **	**5.457*** **	**3.508*** **
No of respondents	**60**	**60**	**60**	**60**

Source: Field Survey, 2020, Note: +Lead equation, ***1% level of significance, ** 5% level of significance, *10% level of significance, Values in parenthesis are the t-value

The Ordinary Least Square result of the effect of socio economic factors on yam processing in Enugu State is presented in Table 3. The linear functional form was chosen as the lead equation.. The coefficient of multiple determination (R^2) was 0.645which implies that 64% of the variations in yam processing was explained by the independent variables included in the model. However, the significant variables were marital status, ,household size, education and membership of cooperative .

The coefficient of marital status and household size were statistically significant and positively related to the yam processing at 1%. This result implied that a unit increase in the household size and marital status of the respondents result to an increase in the yam processing. This is expected because large household size may serve as a means of cheap labour for yam processing activities in the study area. This result is in consonance with Nwaobiala(2018) who reported that relative large household size enhanced availability of labour for increased efficiency among farmers. The coefficient of education was statistically significant and positively related to the yam processing at 1%. This result implied that a unit increase in the educational level of the respondents resulted in increase in the yam production among the respondents. More educated women are likely to adopt new technologies.. The result corroborates with that of Abudu *et al*(2014) who reported that education positively influenced farmers' productivity.

CONCLUSION

The most common improved yam technology used by the respondents was organic manure. The level of participation of women in yam processing in the study area was low. Only yam flour, yam chips and yam flakes recorded high level of participation among the respondents. Marital status, household size and Education exerted significant effects on yam processing in Enugu State.

RECOMMENDATIONS

There is need to guide, educate and encourage women to embark on yam processing to enhance their welfare status

Women should be taught to be more involved in improved yam management technologies than is currently in place in the area

Training on yam value addition is needed among women in the study area for increased participation.

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FACTORS INFLUENCING FARMERS' KNOWLEDGE ON POST-HARVEST MANAGEMENT OF MAIZE IN NIGER STATE, NIGERIA

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ABSTRACT

This study analysed factors influencing farmers' knowledge on post-harvest management of maize in Niger State, Nigeria. A multi-stage sampling technique was used to select one hundred and eighty (180) maize farmers in the study area. Structured questionnaire complimented with interview scheduled were used for data collection. Data collected was analysed using knowledge test and Poisson Regression Model. Finding showed that 57.8% had knowledge score of between 16-20 while 72.7% of the respondents had high knowledge on post-harvest management in maize. The coefficient of age (-.0046825), education (.0095443), farming experience (-.0043662) and storage facilities (0.0391843) influenced farmers' knowledge on post-harvest management in maize. It is recommended that older farmers should be enlightened by extension agents and stakeholders involved in agro-processing on the benefits embedded in post-harvests technologies in order to improve their income and livelihood. Also, the cost of post-harvest materials and tools should be subsidized by government and stakeholders for farmers to access at affordable price as this which will go a long way to enhance farmers' knowledge and probably improved on the level of adoption of post-harvest management.

Keywords: *Factors Influencing Farmers knowledge, Post-harvest Management, Maize*

INTRODUCTION

Maize (*Zea may*) is one of the most widely consumed stable crop in Nigeria. Maize crop thrive in almost all the ecological zones of the country. Larger proportion of the maize produced in Nigeria is carried out by smallholder farmers with inadequate access to incentives that enhance their productivity (Akanbi, Alarape & Olatunji., 2019). Notwithstanding, Nigeria just like other Sub-Saharan African countries produced low output in maize compared to developed countries due to many constraints such as biotic factors or abiotic factors like low soil fertility, pests and diseases, drought, unavailability of improved seed, weeds, less remunerative prices, lack of market opportunities and lack of knowledge on post-harvest management practice in maize (Issa, Kagbu & Abdulkadir, 2016). Maize as a cereal crop requires a lots of post-management practices in other to reduce post-harvest farm losses and also meet up the growing needs of world population. The population of the world is growing rapidly which has resulted to crave increase in consumption. The objectives of the study are to: determine the farmers' knowledge of post-harvest management in maize; and determine the factors influencing knowledge level of maize in the study area.

MATERIALS AND METHODS

The research was carried out in Niger State of Nigeria. The State can be found in the Guinea Savannah ecological zone of Nigeria. The State is located within longitude 3^{o} 30' and 7^{o} 20' East and latitude 8^{o} 20' and 11^{o} 30' North. The State has a population of about 6,220.617 (National Bureau of Statistics (NBS) (2019). However, with a growth rate of 3.2%, the State has estimated population of 6,625,106.376 in 2021 (NBS, 2019). Some of the crops grown in the area are yam, cotton, Shea-butter, maize, sorghum millet, cowpea, soybean, beans, rice and groundnut. Some of the tree crops are Mango, citrus, coconut, cashew, banana, pawpaw. The inhabitants of the State also rear some livestock like goats, sheep, cattle and chicken among others. The other non-agricultural activities engaged in by men include blacksmithing, leatherwork, mat and basket making, trading while women also engage in technical handicraft and trading (Niger State Geographical Information 2015). Multi-stage sampling technique was employed for this study. The first stage involved random selection of three (3) Agricultural zones in the State. The second stage involved random selection of one (1) Local Government Areas from each of the zones making a total number of three (3) LGAs. The third stage involved random selection of four (4) communities each from the selected LGAs making a total of twelve (12) villages. The fourth stage involved the use of proportional sampling to select 10% of the farmers from the sampling frame to give a total of one hundred and eighty (180) respondents. Primary data was used for this study area. Data was collected by the researcher assisted by trained enumerators using structure questionnaire complimented with interview schedules. Objective i was achieved by carrying out knowledge test for the farmers. Knowledge test was based on the post-harvest management used for maize by the farmers. A total number thirty-three (33) knowledge questions in maize were subjected to knowledge test. Knowledge scores were recorded for each farmer. Each of the statements carried a full weight one (1). Farmers were asked to choose one response against alternative responses as right, wrong or I don't know. For each right response, a farmer received a full weight of 1, for each wrong or I don't know, a farmer receives 0. Thus, the knowledge score ranged from 0 to 100, where $\leq$ 25=Very Low Knowledge, 26-50=Low Knowledge, 51-75=High knowledge, >75=Very High Knowledge.

Factors influencing the knowledge level of respondents on post-harvest management was achieved using poisson regression model, both the implicit and the explicit models are specified below:

Knowledge level of farmers' (Y) is a function of =f $(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8X_9......X_n)$

$Y= b_o +b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 +b_5X_5+b_6X_6+b_7X_7+b_8X_8+b_9X_9 + b_{10}X_{10}+b_{11}X_{11+}b_{12}X_{12+}b_n X_n+ U$

Y =Farmers' knowledge on post-harvest management (test scores of post-harvest management by the farmers)

X_1= Age (years), X_2= Sex (Male= 1, Female= 0), X_3= Level of education (years), X_4= Household size (number), X_5= Farm size (hectares), X_6= Farming experience (years), X_7 = Affordability of post-harvest management (affordable =1, not affordable= 0), X_8=Access to storage facilities (number), X_9 = Access to extension (number), X_{10} = Access to credit (yes =1, no= 0), X_{11} =Annual farm income (naira), X_{12} = Cost of acquiring storage facilities (naira), B_1-B_2=coefficient

U = Error term

RESULTS AND DISCUSSION

Total Knowledge Scores of Maize Farmers

Results in Table 1 indicated that 57.8% of the farmers in had knowledge score of between 16-20 in maize while 27.8% had of maize farmers had knowledge score >20. The mean knowledge score of the maize was 18.6. This implies that maize farmers had adequate knowledge on post-harvest management in maize. High knowledge might likely equip farmers with skills and techniques needed to curb post-harvest losses that negatively affect farmers' income and livelihood status.

Table 1: Distribution of the farmers according to total knowledge scores in maize (n=180)

Knowledge Scores	Frequency	Percentage	Mean
1-5	0	0	18.6
6-10	1	0.6	
11-15	25	13.9	
16-20	104	57.8	
>20	50	27.8	

Sources: Field survey, 2018

Farmers Knowledge on Post-Harvest Management in Maize

Table 2 revealed that 72.7% of maize farmers had high knowledge on post-harvest management practices in maize while 26.1% had low knowledge. This implies that greater proportion of farmers had high knowledge. High knowledge is expected to reduce the effect of post-harvest losses thereby increasing the food security and livelihood status of maize farmers.

Table 2: Knowledge of farmers on post-harvest management in maize (n=180)

	Frequency	Percentage
Very high knowledge	2	1.1
High knowledge	131	72.7
Low knowledge	47	26.1
Very low knowledge	0	0

Sources: Field survey, 2018

Factors Influencing Farmers Knowledge on Post-harvest Management of Maize

Poisson regression was used to determine factors influencing farmers' knowledge on post-harvest management. The result in Table 3 indicated Pseudo R^2 of 0.815, implying that about 81.5% of variation in the knowledge on post-harvest management was explained by the independent variables included in the model, while the remaining

19.5% were due to external factor not capture by the researcher. The chi-square statistics 106.98 was significant at 1% level of probability indicating fitness of the model. The coefficient of age (-.0046825) was negative and significant at 1% level of probability, implying that as farmers get older, their knowledge on post-harvest management tend to decrease. The findings agreed with Wango (2016), who stated that majority of farmers with knowledge on Agro-Ecological Intensification The coefficient of education (.0095443) and positively significant at 1% level of probability, this implies that increase in education will lead to increase in knowledge of farmers on post-harvest management. This agreed with Oyewole and Ojeleye (2015) who posited that knowledge of farmers on improved farming practices increased with attainment of higher level of education among farmers in Kano State, Nigeria. The coefficient of education was also positive and statistically significant at 5% level of probability. The coefficient of farming experience (-.0043662) positive and significant at 1% level of probability, this implies that increase in numbers of years in farming will reduce farmers' knowledge on post-harvest management. The coefficient of access to storage facilities (0.0391843) was positive and significant at 1% level of probability, implying that adequate access to storage facilities will increase farmers' knowledge on post-harvest management.

Table 3: Factors influencing farmers knowledge on post-harvest management (n=180)

Variables	Coefficient	Z-value
Age	-.0046825	-2.30**
Sex	.0198703	0.55
Years spent in formal education	.0095443	3.63***
Household size	.0196125	6.18***
Farm size	-.0080505	-0.79
Farming experience	-.0043662	-2.32**
Affordability of post-harvest tech	-.1439616	-3.66***
Access to storage facilities	.0391843	2.74***
Access to extension	.0051384	0.53
Access to credit	.0906295	2.60***
Annual farm income	3.32e-08	0.31
Cost of acquiring storage facilities	-7.25e-08	-0.37
Constant	3.532228	46.19***
Pseudo R2	0.815	
Chi square	106.98***	
Log likelihood	-602.95594	

Sources: Field survey 2018

*** Significant at 1% level of probability, **=Significant at 5% level of probability, *=Significant at 10% level of probability

CONCLUSION AND RECOMMENDATIONS

Based on this finding it can be concluded that majority of maize farmers had high knowledge on the post-harvest management of maize. Also, the coefficient of age, education, household size, farming experience, affordability of post-harvest management, access to storage facilities, and access to credit had influenced on farmers' knowledge on post-harvest management. It is recommended that older farmers should be enlightened by extension agents and stakeholders involved in agro-processing on the benefits embedded in post-harvests technologies in order to improve their income and livelihood. Also, the cost of post-harvest materials and tools should be subsidized by government and stakeholders for farmers to access at affordable price as this which will go a long way to enhance farmers' knowledge and probably improved on the level of adoption of post-harvest management.

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COMPARATIVE ANALYSIS OF DRYING TECHNIQUES ON QUERCETIN, RUTIN AND TANNIN ACID CONTENT IN GINGER: IMPLICATION FOR NUTRITIONAL PRESERVATION

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ABSTRACT
The purpose of this study was to see how different drying procedures affected the concentration of three essential bioactive chemicals, namely Quercetin, Rutin, and Tannin acid, in ginger extract. The drying methods investigated were shade drying, freeze drying, vacuum oven drying, and fresh without any drying treatment. The concentrations of the compounds were measured in milligrams per gram (mg/g) in triplicate using high performance liquid chromatography. The results demonstrated substantial changes in compound concentration across drying processes, with Freeze drying and Vacuum Oven drying showing higher amounts than Shade drying and Fresh sample. For Quercetin, Vacuum oven drying showed the greatest concentration (1.352 ± 0.062), followed by vacuum oven drying (1.253± 0.057) and shade drying (0.964± 0.045). Fresh samples, on the other hand, had the lowest Quercetin content of 0.499± 0.023.Rutin concentrations followed a similar pattern, with vacuum oven drying producing the greatest concentration (0.541± 0.027), freeze drying (0.468 ±0.023), shade drying (0.425± 0.021), and fresh samples (0.211± 0.012).Furthermore, freeze-dried samples showed the greatest tannic acid contents (0.351± 0.018), followed by vacuum oven drying (0.326± 0.016), shade drying (0.278± 0.014), and fresh samples (0.153 0.009). This research provides important insights into optimizing the drying process to preserve and enhance the bioactive chemical content of ginger.

INTRODUCTION
Citronbergetal; *(*2013) opined that plant-derived compounds, particularly Quercetin, Rutin, and Tannin acid, have received significant attention as a result of their potential health benefits which include, antioxidant, anti-inflammatory, and anticancer properties. However, the choice of drying method applied can have significantly impact on the concentration of these bioactive compounds.
Zhang *et al*; (2016) and Nile and Park, (2015) reported that ginger (*Zingiber officinale*) apart from being a popular spice; also have health and medicinal advantages. Its bioactive components, include quercetin, rutin, and tannic acid which are believe to be responsible for its wide range of pharmacological activities, including antioxidant anti-inflammatory anti cancer, anti-fungi and antibacterial effects.
The usefulness of ginger in relieving nausea has been observed in certain research investigations (Grante*etal;* 2000). A common preservation technique that can change the composition of these chemicals is drying. The influence of various drying methods on the retention of ginger's bioactive components may differ. In this study, four distinct drying techniques—shade drying, vacuum oven drying, freeze drying, and fresh ginger were used to evaluate and compare the quercetin, rutin, and tannic acid content of the ginger.

METHODOLOGY
Sample Collection and Preparation
The sample for this investigation was chosen with care.For each drying technique, the sample was cleaned, weighed, and divided into four equal pieces.

Drying procedures
Four distinct drying procedures were used: shade drying, freeze drying, vacuum oven drying, and a fresh ginger (*Zingiber officinale*) that will serve as control.

Extraction and Analysis of Compounds
Methanol was used as the extracting solvent for the dried and fresh ginger samples. 5g of the weighed samples were refluxed with methanol (100ml) for 15 minutes in a water bath and filtered through Whatman filter paper (No.41). The residue was refluxed three times with 70ml of methanol for 15 minutes and filtered. The solvent was

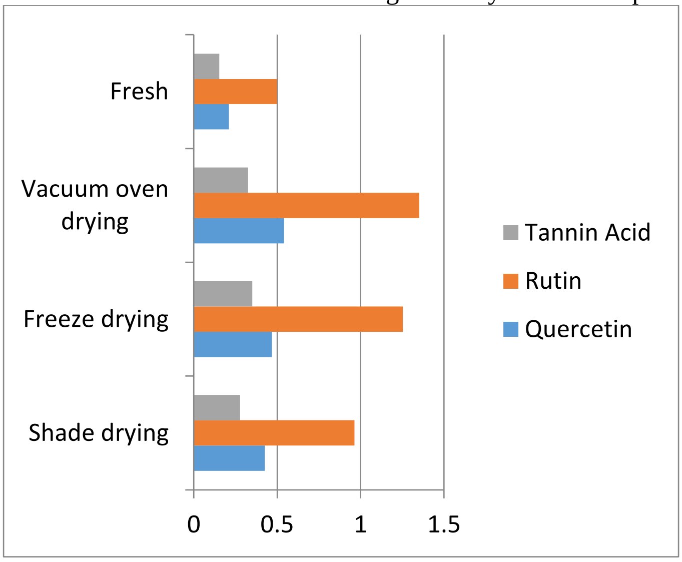
then evaporated using a rotary vacuum evaporator. This procedure was performed for all the samples. The extract was analyzed using High performance liquid chromatography. Statistical Analysis: ANOVA was used to examine the significance of differences between the means of the different drying processes.

RESULTS AND DISCUSSIONS:

The analysis's findings revealed considerable differences in the amounts of quercetin, rutin, and tannic acid among the various drying techniques. In milligrams per gram (mg/g) **of** dried ginger, the mean values and standard deviations for each constituent are shown in Table below.

Drying Method	Quercetin (mg/g)	Rutin (mg/g)	Tannin acid (mg/g)
Shade drying	0.425 ± 0.021 c	0.964 ± 0.045 c	0.278 ± 0.014c
Freeze drying	0.468 ± 0.023 b	1.253 ± 0.057b	0.351 ± 0.018a
Vacuum Oven drying	0.541 ± 0.027 a	1.352 ± 0.062a	0.326 ± 0.016b
Fresh	0.211 ± 0.012 d	0.499 ± 0.023d	0.153 ± 0.009d

The Data represents means of triplicate measurements. The means that are not sharing a common letter in each column for each measurement are significantly different at $p<0.05$



Quercetin content : Freeze drying and vacuum oven drying significantly enhanced the Quercetin content (1.253± 0.057 mg/g and 1.352 ±0.062 mg/g, respectively) as compared to shade drying (0.964± 0.045 mg/g) and fresh sample (0.499± 0.023 mg/g). This implies that both freeze drying and vacuum oven drying are more effective at preserving Quercetin content.
Rutin content : Freeze drying (0.468 ±0.023 mg/g) and vacuum oven drying (0.541± 0.027 mg/g) both exhibited significantly higher Rutin content than shade drying (0.425 ±0.021 mg/g) and fresh sample (0.211± 0.012 mg/g). These findings demonstrate the ability of freeze drying and vacuum oven drying to retain rutin content.
Tannin acid Content: Tannin Acid levels were greater after freeze drying (0.351± 0.018 mg/g) and vacuum oven drying (0.326 ±0.016 mg/g) than after shade drying (0.278 ±0.014 mg/g). Tannin Acid content did not differ

significantly between freeze drying and vacuum oven drying. Tannin Acid concentration was lowest in the Fresh sample (0.153± 0.009 mg/g).

CONCLUSION

This study clearly shows that the drying method used has a substantial impact on the concentration of bioactive compounds in the sample. Freeze drying and vacuum oven drying were discovered to be preferable strategies for conserving and improving the Quercetin, Rutin, and Tannin Acid levels. These discoveries are critical for enterprises producing herbal medicines and plant-based foods, as they can adjust their drying methods to maximize the retention of key bioactive components. Further research should be conducted to investigate the possible influence of these drying processes on other bioactive compounds, as well as to assess the effects on product quality and shelf life.

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ADOPTION OF CASSAVA STARCH PROCESSING TECHNOLOGIES IN ENUGU STATE, NIGERIA

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ABSTRACT
Adoption of cassava flour processing technologies in Enugu State, Nigeria was studied. Data were obtained from 120 respondents using questionnaire and oral interview schedule. Percentage response and probit model analysis were used to address the objectives of the study. The farmers' educational level and extension services were the socioeconomic determinants to the adoption of improved starch processing technologies in the study area. Enhancing processors' access to educational level and extension services were recommended.
Keywords: *Adoption, Cassava Flour, processing technologies, Enugu State, Nigeria*

INTRODUCTION
Cassava starch is a whitish, powdery material, which is used is used to produce such diverse products as food, paper, textiles, adhesives, beverages, confectionery, pharmaceuticals and building materials (Alinnor, 2002). Starch is derivatives from grain or root crops, however, the latter is more preferred. According to IITA, (2014) cassava starch has intrinsic characteristics, including high paste viscosity, high paste clarity, and high freeze-thaw stability, which are advantageous to many industries.
Starch as asserted by Food Agriculture and Organization, (FAO), (2017) can be produced through the following processing steps: sorting of cassava, peeling and washing of the root, grating, soaking the root for fermentation, milling, drying and storage.
The improved processing technologies were disseminated for onward adoption by the processors courtesy of extension services arm of Agricultural Development programme (ADP) (Ume, Onwujiariri and Nwaneri, 2020). However, information on the rate or extent of adoption of the technologies is not yet known. Therefore, the need to abridge this research gap, especially as it is influenced by the processors' socioeconomics characteristics. Specifically, the objectives of the study were to: describe the socioeconomic characteristics of the farmers and determine the extent of the adoption of the technologies.

MATERIALS AND METHODS
Enugu State lies between latitudes 6°30'N and 7°10'N of Equator and longitudes 6°35' E and 7°30' E of Greenwich Meridian. The state has an estimated population of about 4, 1671 million people (NPC, 2006) and land area of 16,727 square km^2.The inhabitants were mainly agrarians and still engage in non-agricultural activities. A well-structured questionnaire was used to collect data for the study. Multi-stage random sampling technique was used to select one hundred and twenty farmers for the study. Percentage response and probit model analysis were used to address the objectives of the study.

Probit model
It is represented as: $Y_i = B^1 X_1 . Xn + e$ ……………..(1)
$Y_i = 0$ if $Y_i < 0$; $Y_i = 1$ if $Y_i > 0$
Where Y_1 = an underlying latent variable that indexes use of the technology, Y_1 = observable dummy variable that indexes use of the technology (used = 1, not used = 0, b_1 = a vector of estimated parameter,X_1 = individual

characteristics of the respondents, e = error term .The model is specified in an implicit form as follows: Y= F (X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8 + ei)………..(2)
Where :Y = Adoption rates (%), X_1 = Age in years, X_2 = Educational level in years, X_3 = Household size in persons, X_4 = Years of farming experience in years, X_5 = Extension contact.(Dummy), ei = Error term.

RESULTS AND DISCUSSIONS

Table1: Socioeconomic Characteristics of the Respondents

Variable	Frequency	Percentage
Age		
24 – 40	48	40
Above 40	72	60
Educational Level		
None	20	16.7
Primary	50	41.7
Secondary	40	33.3
Tertiary	10	8.3
Household Size		
1 – 6	40	33.3
7 and above	80	66.7
Farming Experience		
1 -10	38	31.7
11- 40	82	68.3
Access to Extension services		
Access	30	25
No Access	90	75

Sources: Field survey, 2022

Table 1 shows that 60% of the respondents were above 40 years that dominated adoption of starch processing technologies in the study area. Aged processors not only have the agility to surmount the stress and strains associated with starch processing, but as well efficient in resource use (Ume, *et al*; 2020). Most (83.3%) of the sampled processors had formal education. Educated people are often prudent in resource management and as well not technology adoption friendly (Nweke, *et al* 2001). Most (66.7%) of the respondents had large household sizes ranging from 7 years and above. This connotes availability of cheap labour for processing, especially if the members are of labour age and still living with the household head (Adeoye-Agomoh, Ume, and Chukwu, 2022). Further, 68.3% of the respondents had processing experience of 11-40 years, while the least (31.7%) had an experience of 1 -10 years. Experienced processors could be able to distinguish among technologies for better options to be taking as reported by Ume, *et al* (2020). Besides, 75% of the respondents had no access to extension services, hence delimiting their exposures to extension services such as having technical assists in implementing certain intricate technologies, hence leading to non-adoption no matter how economical feasible and technically efficient the technology could be (FAO, 2017).

Table 2: Result of Probit Analysis

Variable	Coefficient	StdError	Z
Constant	- 1.791	0.030	(59.226)***
Age	0.012	0.013	(6.927)***
Educational level	0.033	0.013	(2.538)**
Household size	0.001	0.002	(0.419)
Farm. Experience	0.040	0.041	(0.976)
Extension contact	-0.015	0.001	(11.710)***
No of Observation	120		
LR chi^2 (19) =	89.33		
Pseudo R^2	0.3821		
Probit> chi^2	0.0027		
Log likelihood	-69.657264		

*, ** and *** implies significant at 10%, 5% and 1% respectively, Figures in parentheses are the t-ratio
Source; Field Survey, 2021

The result in Table 2 shows that there was an inverse relationship between processors' age and technology adoption. The decrease in the adoptability of individuals with advancement in age could be cited to explain the correlation (IITA, 2014). Also, the positive sign of the coefficient of education with technology adoption, implying that high educational status of the processor could expedites adoption of technologies. This could be because educational attainment enhances individual access to information in order to be more objective in evaluating innovations, which would directly influence his/her processing enterprise (Alinnor, 2002). Additionally, coefficient of extension services was positively related to the rate of adoption and significant at 1% probability level. Extension services aid in educating processors on importance of technology adoption in enhancing their productivity. The finding of Adeoye-Agomoh, *et al.*(2022), agreed with the above statement. They reported on the import of extension agents in giving processors information on input sources in order to ease technologies adoption.

CONCLUSION AND RECOMMENDATION

The farmers' educational level and access to extension services were the socioeconomic determinants to the adoption of improved starch processing technologies in study area. There is need to enhance farmers' level of education through workshops, seminars and adult education. Furthermore, extension agents should be adequately motivated through prompt payment of their salaries and other out of pocket expenses incurred during the discharge of their functions

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PERCEPTION OF MAIZE FARMERS' ON THE BENEFITS OF POST-HARVEST MANAGEMENT AND CONSTRAINTS IN NIGER STATE, NIGERIA

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ABSTRACT
This study determines the perception of maize farmers' on the benefits of post-harvest management and constraints in Niger State, Nigeria. A multi-stage sampling technique was used to select one hundred and eighty (180) maize farmers in the study area. Structured questionnaire complimented with interview scheduled were used for data collection. Data collected were analysed using frequency, percentage and mean. Finding showed that the mean age of maize farmers was 42years while 80% of maize farmers were males. Also, maize farmers agreed that post-harvest management is good at meeting farmers need in time of food scarcity ($\bar{X}$ =4.16), post-harvest management improved farmers income($\bar{X}$ =4.12) and post-harvest management are not too difficult to finance with mean value of ($\bar{X}$ =4.01). the most constraints associated with post-harvest management were inadequate training (97.2%), shortage of fund (95.0%) and iinadequate credit facilities (91.7%). It is recommended that that credit and fund should be made available by governments and non-governmental organization so that farmers' could purchase post-harvest tools that are needed to enhance the longevity of agricultural produce. Post-harvest materials and tools should be subsidized by government and stakeholders for farmers' to access at affordable price.
***Keywords**: Benefits, Constraints, Maize farmers, Post-harvest management.*

INTRODUCTION
Maize is one of the most widely consumed cereal crop in Nigeria. Maize is grown in almost all the ecological zones of the country, although with different in yield and productivity. Maize is mostly produced by smallholders with inadequate access to incentives that enhance their productivity (Akanbi *et al.*, 2019). Maize is rich in carbohydrate, protein, iron, vitamin B and minerals (Oyelami *et al.* 2018). It is also used as food mostly especially in infants and feeding of farm animals. Maize crop cannot withstand too much of stress and despite been grain in nature, it is highly susceptible to post-harvest losses due to activities of weevil and other insect (Oyelami *et al.* 2018). According to Saran *et al.* (2012), majority of the agricultural produce maize inclusive in developing countries experience lost due to inadequate post-harvest management. The losses often encountered by farmers most times forced them to sell produce at the point of production only to buy back at highly exorbitant prices few months after harvesting. It is expected that post-harvest management practices such as preservation, conservation, quality control/enhancement, processing, packaging, storage, distribution, marketing will reduce the post-harvest losses encounter by maize farmers (Pelemo *et al.*, 2018). The study determine perceived benefits of post-harvest management of maize in Niger State of Nigeria. The specific objectives are to: describe the socio-economic characteristics of respondents in the study area, determine the perceived benefits of post-harvest management of maize and identify the constraints to post-harvest management.

METHODOLOGY
The research was conducted in Niger State of Nigeria. The State can be found in the Guinea Savannah ecological zone of Nigeria. In terms of land mass, it is the largest State in Nigeria. It covers a total land area of 74,224km^2 thus accounting for about eight percent of Nigeria's land area (Niger State Geographical information system, 2015). It is located within longitude 3° 30' and 7° 20' East & latitude 8° 20' and 11° 30' North, with a population of about 3,950,249 (NPC, 2006) and with a growth rate of 3.2%, the State has estimated population of 5,586,000 in 2017 (Niger State Geographical Information System, 2015). The most predominant soil type is the ferruginous tropical soils. The soils are fertile, its hydrology permit the cultivation of most of Nigeria staple crops and still allows sufficient opportunities for grazing, fresh water fishing and forestry development. Some of the crops grown in the area are yam, cotton, Shea-butter, maize, sorghum millet, cowpea, soybean, beans, rice and groundnut.

Some of the tree crops are Mango, citrus, coconut, cashew, banana, pawpaw. The inhabitants of the State also rear some livestock like goats, sheep, cattle and chicken among others. Multi-stage sampling technique was used for this study. The first stage involved random selection of three (3) Agricultural zones in the State. The second stage involved random selection of one (1) Local Government Areas from each from the selected zones making a total number of three (3) LGAs. The third stage involved random selection of four (4) communities each from the selected LGAs making a total of twelve (12) villages. The fourth stage involved the use of proportional sampling to select 10% of the farmers from the sampling frame to give a total of one hundred and eighty (180) respondents. Primary data was used for this study area. Data was collected by the researcher assisted by trained enumerators using structure questionnaire complimented with interview schedules. Objectives of the study were achieved using descriptive statistics such frequency distribution, percentages and mean

RESULTS AND DISCUSSION

Socio-economic Characteristics of Maize Farmers

Results in Table 1 revealed that the mean age of the farmers was 42 years. This indicates that maize farmers were still in theire active and productive age. This finding is in line with Rashid *et al.* (2015) reported that post-harvest practices were mostly dominated by young farmers in Ekiti. Results in Table 1 indicated that majority (80.0%) of maize farmers were males. This finding showed that majority of the farmers in both States were males. Male dominance might be attributed to women involvement in domestic and other farm activities. Results in Table 1 showed 48.3% of maize farmers had no access to extension. This finding indicated that more than half of the farmers did not access extension. Access to extension to some extent is expected to improve skills, knowledge and perception of farmers' on post-harvest management, this is because access to extension grant farmers opportunity to access new innovation that will improve their income and livelihood. This finding agreed with Barnabas *et al.* (2019*)*, who reported that majority of farmers in Kogi State, Nigeria had access to extension services. Results in Table 1 indicated that 63.3% of maize farmers in belong to cooperative. This result showed that more than half of the farmers belong to cooperatives. Entries in Table 1 further indicated that 22.8% of the farmers had access to credit This results showed that majority of maize farmers did not have access to credit. This scenario could negatively affect farmers with low income status who cannot afford to acquire post-harvest materials.

Table 1: Distribution of the farmers according to socio-economic characteristics (n=180)

Variables	Frequency	Percentage	Mean
Age			
$\leq$30	31	17.2	42
31-40	45	25.0	
41-50	67	37.2	
51-60	34	18.9	
>60	3	1.7	
Sex			
Male	144	80.0	
Female	36 (20.0)	20.0	
Household size (number)			
1-5	42	23.3	9
6-10	89	49.4	
11-15	41	22.8	
16-20	4	2.2	
>20	4	2.2	
Access to extension			
Accessed	87	48.3	
Not accessed	93	51.7	
Cooperative membership			
Yes	114	63.3	
No	66	36.7	
Access to credit			
Yes	41	22.8	
No	134	77.2	

Sources: Field survey, (2018)

Perception of Farmers on the Benefits of Post-Harvest Management in Maize

The results in Table 2 showed that maize farmers agreed that post-harvest management is good at meeting farmers need in time of food scarcity ($\bar{X}$ =4.16), post-harvest management improved farmers income ($\bar{X}$ =4.12). This finding was in agreement with Anyawun and Mendie (2017), who stated that utilization post-harvest management have ability of increasing income and livelihood of farming populace in rural areas. Also, farmers agreed that post-harvest management are not too difficult to finance with mean value of ($\bar{X}$ =4.01), implying that adoption of post-harvest management do not requirement huge amount of capital. Maize farmers further agreed that post-harvest management improved farmers produce shelf life ($\bar{X}$ =3.86), post-harvest management increase farmers standard ofliving ($\bar{X}$ =3.82), post-harvest management grants farmers more market opportunities with mean value of ($\bar{X}$ =3.82), post-harvest management meet farmers daily food needs ($\bar{X}$ =3.80), post-harvest management are compatible with farmer indigenous food preservation ($\bar{X}$ =3.79) and post-harvest management enhance quality of farmers produce with mean value of ($\bar{X}$ =3.79). However, maize farmers disagreed with the following statements; post-harvest management expose farmers to extension ($\bar{X}$ =2.98), post-harvest management keep farmers produce cool all through the year with mean value of ($\bar{X}$ =2.95), post-harvest management do not increase farmers' standard of living with mean value of($\bar{X}$ =2.82), and post-harvest management give lower returns with mean value of ($\bar{X}$=2.16).

Table 2: Perception farmers' on the benefits of post-harvest management in maize (n=180)

Perception Statements	SA	A	UN	DA	SD	Sum	Mean ($\bar{x}$)	R	D
ost-harvest management is good at meeting farmers need in time of food scarcity	76 (42.2)	80 (44.4)	8 (4.4)	8 (4.4)	8 (4.4)	748	4.16	1st	A
Post-harvest management improved farmers income	80 (44.4)	70 (38.9)	11 (6.1)	10 (5.6)	9 (5.0)	742	4.12	2nd	A
Post-harvest management are not too difficult to finance	80 (44.4)	64 (35.6)	8 (4.4)	13 (7.2)	15 (8.3)	721	4.01	3rd	A
Post-harvest management improve farmers produce shelf life	38 (21.1)	111 (61.7)	10 (5.6)	9 (5.0)	12 (6.7)	694	3.86	4th	A
Post-harvest management increase farmers standard ofliving	39 (21.7)	108 (60.0)	10 (5.6)	8 (4.4)	15 (8.3)	688	3.82	5th	A
Post-harvest management grants farmers more market opportunities	66 (36.7)	72 (40.0)	8 (4.4)	12 (6.7)	22 (12.2)	688	3.82	5th	A
Post-harvest management meet farmers daily food needs	28 (15.6)	119 (66.1)	12 (6.7)	11 (6.1)	10 (5.6)	684	3.80	7th	A
Post-harvest management expose farmers to extension	42 (23.3)	40 (22.2)	11 (6.1)	46 (25.6)	41 (22.8)	536	2.98	8th	D
Post-harvest managementdo not increase farmers' standard of living	21 (11.7)	59 (32.8)	10 (5.6)	46 (25.6)	44 (24.4)	507	2.82	9th	D
Post-harvest management give lower returns	18 (10.0)	23 (12.8)	8 (4.4)	52(28.9)	79 (43.9)	389	2.16	10th	D

Sources: Field survey, 2018

Note: SA= Strongly agreed, A=Agreed, UN=Undecided, DA=Disagreed, SD=Strongly disagreed R=Ranking, D=Decision

Constraints associated with post-harvest management

Table 2 showed that inadequate training (97.2%) was the most constraints associated with post-harvest management in the study area. This implies that farmers did not have access to enough training on post-harvest management in maize. This finding concurs with that of Johnson *et al.* (2016), who stated that inadequate training was the major constraints faced by smallholder farmers in Sub-Saharan Africa. Shortage of fund (95.0%) was ranked 2nd, implying that maize farmers lack access to adequate fund. The finding is in consonance with that of Mohammed *et a*l. (2018) who indicated that shortage of fund and inadequate access to credit were the major constraints affecting soya bean production in Northern Region of Ghana. Inadequate credit facilities (91.7%), signifying low access to credit whether from formal or and non-formal sectors. Other constraints associated with post-harvest manage were high cost of post-harvest materials (85.6%), lack of farmers' participations (81.1%) and transportation challenge (80.0%) ranked 3rd, 4th, 5th and 6th respectively.

Table 2: Constraints associated with post-harvest management (n=180)

Variables	Frequency	Percentage	Ranking
Inadequate trainings on post-harvest	175	97.2	1st
Shortage of funds	171	95.0	2nd
Inadequate credit facilities	165	91.7	3rd
High cost of post-harvest materials	154	85.6	4th
Lack of farmers participations	146	81.1	5th
Transportation challenge	144	80.0	6th
Loss in market value	121	67.2	7th
Insect attacks	120	66.7	8th
Inadequate market information	116	64.4	9th
Disease attack	98	54.4	10th

Sources: Field survey, 2018

CONCLUSION AND RECOMMENDATIONS

Based on this finding it can be concluded that majority of maize farmers were male in their active age. Also, maize farmers agreed that post-harvest management is good at meeting farmers need in time of food scarcity, post-harvest management improved farmers' income and post-harvest management are not too difficult to finance. The most constraints associated with post-harvest management were inadequate training, shortage of funds and high cost of post-harvest materials. It is recommended that credit and fund should be made available by governments and non-governmental organization so that farmers' could purchase post-harvest tools that are needed to enhance the longevity of agricultural produce. Post-harvest materials and tools should be subsidized by government and stakeholders for farmers' to access at affordable price.

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IMPACT OF POSTHARVEST MANAGEMENT PRACTICES ON FOOD SECURITY AMONG FEMALE HEADED HOUSEHOLDS IN IVO LGA OF EBONYI STATE

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ABSTRACT
The study was on impact of postharvest management practices on food security among female headed households and intended to describe the socio-economic characteristics, examine the impact of post-harvest management practices on food security, and assess the factors influencing food security among female headed households. The study area was Ivo LGA of Ebonyi state. The study was based on responses from 95 respondents collected with the aid of a well-structured questionnaire. Descriptive statistics such as frequencies, percentages, ranking and, mean scores were used in this study while the inference was made with the aid of Pearson Correlation analysis. Results show that the average age and household size was 32 years and 6 persons respectively, occupation type showed that 42.1% of the respondents are sole farmers while 48.4% of the respondents have secondary school certificate. Outcome of the Pearson Correlation (r) shows that postharvest management practices have a very weak but positive relationship on the food security of female headed households. Ethnic conflicts, income size and number of dependents were ranked respectively as 1st, 2nd and 3rd major factors influencing food security among female headed households. The study concludes that there is no meaningful relationship between postharvest management practice and food security status among female headed households based on the lack of statistical significance. It recommends that efforts should be made by government to instil peace between communities. Also, there is need for government intervention on the female headed households to assist in providing solace to the household. Finally, policies that will be favourable to female headed households such as ease of access to farmland should be implemented.

***Keywords**: Female headed household, Food security, Postharvest management practices.*

INTRODUCTION

There is no doubt that food is one of the basic needs of every human being and this has made it compulsory to boost food production with the development, introduction, and adoption of improved technologies. Agriculture remains central to most African countries economies and its 169 growth has major implications for the region's food security and poverty reduction (Onyeneke *et al.*, 2019). Food value chain systems should take into consideration the need for proper post-harvest management. This can be achieved by early harvesting and storing techniques with controlled on farm drying practices (Osuji *et al.*, 2021). Post-harvest practices have been there for decades ranging from traditional storage systems to modern ones (Adikwu *et al.*, 2023). Post harvest management practices are the methods engaged in the handling of agricultural produces from farm to table (harvesting, transporting, and handling, storing, processing) (Bekele, 2021).

Food security indices have been measured globally using various indicators such as per capita expenditure on food, food insecurity access scale, food consumption score, per capita food consumption (FAO, 2022). Food security is achieved when all four pillars – availability, access, utilization, and stability- are met (FAO, 2022). Availability ensures there is a trustworthy and consistent source of food; access concerns the capability of individuals in having sufficient resources to produce and/or purchase adequate food; utilization deals with people having adequate knowledge and fundamental sanitary conditions to select, prepare and distribute food capable of providing good nutrition; while stability sees to the sustenance of the availability, access and utilization over time (Swiss Agency for Development and Cooperation (SDC, 2017). The target of food security is to make sure the health of individuals and households are secured. According to Elemasho *et al.*, (2022) post-harvest loss is a serious threat to food security and inefficiency in the global food system. Postharvest loss is the degradation in both quality and quantity of a food production from harvest to consumption. Continuous high loss of staple crops has a significant negative impact on food security (Morris *et al.*, 2019). The long-term effect of post-harvest loss is the loss of interest in farming.

Female headed households is one which has the head of the household as a female because of the male head been absent dead or unavailable for about a year or more), with major decisions as well as economic provision of the household resting on the female (Milazzo and Van de Walle, 2022). The rate of female headed households is different in various countries but has increased in developing countries over the half century because of divorce, spouse death, addiction or disability of husband, increased life expectancy among women migration or being abandoned by husband (Horrel and Krishnan, 2007). Food security at female headed household is worse in developing countries (Lutomia *et al.*, 2019). To better understand the challenges and problems of female headed households, there is need for qualitative research that covers all aspects of their lives and shows their living conditions from the perspective of their own experiences and views. Therefore, this study intends to describe the socio-economic characteristics, examine the impact of post-harvest management practices on food security, and factors influencing food security among female headed households.

METHODOLOGY

The study area for this study was Ivo LGA of Ebonyi state. It is geographically situated between latitude 5° 36^1 and 6° 59^1 N and longitude 7° 35^1 and 7° 4^l E. It covers an Area of 3506 Sqkm^2 with population of about 220,919 people (NPC, 2006). The rainfall ranges from 1500-2500mm, temperature ranges from 28-45° and moderate relative humidity of 65%. A Purposive and multistage random sampling technique was employed in selecting respondents for this study. Five (5) villages were randomly selected from two (2) autonomous communities in the study area (=10 villages), ten (10) households headed by females were purposively selected from the selected villages. This will give a sample size of hundred (100) female house heads. Analysis was subject to only ninety-five (95) returned questionnaires by the respondents. Descriptive statistics such as frequencies, percentages, ranking and, mean scores was used in this study while the inference was made with the aid of Pearson Correlation analysis.

RESULTS AND DISCUSSION

Socio-economic characteristics of the respondents.

The socio-economic characteristics discussed in this study includes age, level of education, employment status, and household size.

The results showed that most of the respondents (34.7%) belong to the age bracket of 30-34 years, the respondents within the ages 25-29 years represent 18.9 % of the respondents, 17.9% of the respondents belonged to age group of 20-24 years while 14.7% of the respondents belong to the age group of 35-39 years and 13.7% belonged to age group of 40-44 years. The average age of the respondents was at 32 years. This result implies that most of the respondents are youths and fall within the active age group. This is in line with a study by Omotesho and Muhammad-Lawal (2013) which states that most respondents are early youths who are active and possess the strength to go about their daily economic activities. Also, table 1 revealed that most respondents (52.6%) have a household size of between 7-9 people, while 29.5% of the respondents had household of 4-6 people and 17.9% of the respondents had a household of 1-3 people. The average household size of the respondents is 6 people. This shows that the respondents have a moderate household size. This is in a disagreement with a study by Onweremadu and Asiabaka (2013) which states that most female headed households have a high family size.

The table also shows that 48.4% of the respondents used for this study had secondary school certificate as their highest form of education, the respondents with primary school certificate was represented by 26.3% of the respondents while 16.8% of the respondents had tertiary education certificate and 8.4% of the respondents had no formal education. This implies that the females heading their households in the study area are formally educated. This disagrees with a study by Ugo (2020) that most rural female headed household are headed by females who have no school certificate.

Table 1; Socio-economic characteristics of respondents for this study

Variables	Frequency	Percentage	Mean score
Age (years)			**32 years**
20-24	17	17.9	
25-29	18	18.9	
30-34	33	34.7	
35-39	14	14.7	
40-44	13	13.7	
Household size (persons)			**6 persons**
1-3	17	17.9	
4-6	28	29.5	
7-9	50	52.6	
Occupation type			
Civil/public servant	31	32.6	

Sole farmer	40	42.1
Business owner	24	25.3
Educational qualification		
No formal schooling	8	8.4
Primary school certificate	25	26.3
Secondary school certificate	46	48.4
Tertiary level certificate	16	16.8

Impact of post-harvest management practices on food security among female headed household.

A Pearson correlation coefficient was computed to find the linear relationship between postharvest management practises and food security status among the female headed household in the study area. The correlation coefficient between postharvest management practices and food security status of female headed households was calculated to be 0.054. This value suggests a weak positive correlation between both variables, indicating a minimal linear relationship between them. The result however is against a study by Ogundele (2022) which state that a reduction in food losses through appropriate post-harvest management practices will improve food security.

Table 2; Correlation between food security status and post-harvest management practices

	FSS	*PHMP*
Pearson Correlation	*1*	*.054*
Sig. (2-tailed)		*.606*
N	*95*	*95*
Pearson Correlation	*.054*	*1*
Sig. (2-tailed)	*.606*	
N	*95*	*95*

- *PMHP (Post harvest management practises), FSS (Food security status)*
- *r(93)=.054,p>.05 (positive but very weak relationship/ not significant)*

Factors influencing food security among female headed households.

The results in table 3 showed that 96.8% of the respondents affirm that ethnic conflicts within the area is ranked as the 1st influence of food security among female headed household followed by income size of female head ranked 2nd with 91.6%, number of dependents, farm size and insecurity on the road is ranked as 3rd, 4th, and 5th respectively with 89.5%, 84.2% and 64.2%. Climate change is ranked 6th with 53.7%, access to credit ranked as 7th while poor post-harvest processing and storage is ranked at 8th with 45.2%. The least factor ranked 9th was the level of education at 41.1%. This result agrees with a study by Henri-Ukoha *et al.* (2013) which showed that female headed households are highly vulnerable and income, farm size and so on have implication for food security and are determinants to food security among female headed households.

Table 3; Ranking of factors influencing food security among female headed households.

Influencing factors	**Frequency***	**Percentage (%)**	**Ranking**
Climate change	51	53.7	6th
Ethnic conflicts	92	96.8	1st
Insecurity on the road	61	64.2	5th
Income size	87	91.6	2nd
Access to credit	50	52.6	7th
Level of education	39	41.1	9th
Farm size	80	84.2	4th
Number of dependents	85	89.5	3rd
Poor post-harvest processing and storage techniques	43	45.2	8th

*Multiple responses recorded

CONCLUSION AND RECOMMENDATIONS.

The study concludes that there is no meaningful relationship between postharvest management practice and food security status among female headed households based on the lack of statistical significance. It recommends that efforts should be made by government to instil peace between communities. Also, there is need for government intervention on the female headed households to assist in providing solace to the household. Finally, policies that will be favourable to female headed households such as ease of access to farmland and so on should be implemented.

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EVALUATION OF HEAVY METALS CONTENT IN CASSAVA FLOUR CONSUMED IN IGBOORA, OYO STATE

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ABSTRACT
Analysis was carried out on some selected cassava flour to determine heavy metals content in some cassava flour sold in Igboora, Oyo state. At 3 selected sites and markets, three samples were collected, digested and analyzed. Copper, Nickel, Lead, Manganese, Arsenic, Chromium and Zinc were determined using atomic absorption spectrophotometer (AAS BULK 220). The concentration of lead in the samples from Towobowo, Oja onilado and Oja oba were 0.14 mg/kg, 0.424 mg/kg, and 0.28 mg/kg respectively. Concentration of manganese from three samples varies from 0.013 mg/kg to 0.031 mg/kg. The highest value for chromium from all the samples was 0.001 mg/kg. Zinc gave the highest concentration of 4.55 mg/kg in Oja oba samples. While the concentration of ranges from 0.06 mg/kg to 0.34mg/kg. The highest concentration of Nickel from all samples was 0.361 mg/kg. However, all the samples showed Cadmium and Arsenic content to be below detection limit. Results showed that the heavy metals content copper, nickel, lead, manganese, arsenic, chromium and zinc (except for lead in samples from Oja Oba and Oja Onilado which was slightly higher) in these food samples falls within permissible limits when compared with FAO/WHO recommended values.
Keywords: *Cassava flour, Concentration rates, Atomic absorption spectrophotometer, Heavy metals*

INTRODUCTION
Cassava (Manihot spp) is the most staple food crop in tropical Africa. It has high adaptivity to a variety of ecological conditions which makes it the most important famine reserve crop (Onwueme, 1978). Current trend in cassava production indicated that the production is increasing globally and the growing of cassava is expanding to semi arid areas (WHO, 2001). Cassava can be consumed either raw (i.e. boiled) or in a variety of processed forms known by different names depending on local customs and preferences. Despite the high level of cassava production, Nigeria consumes virtually all that are produced. The household's consumption can be transformed into a number of products both for domestic and industrial uses (Abdullahi, 2003). Cassava can be classified into two broad forms; fermented and unfermented cassava, based on the processing technology. There are four major forms of cassava products; meal, chips, flour and starch (Wheatley, 1993). Cassava flour is gaining fast recognition as a good substitute for wheat flour in the bakery, biscuit and fast food industries (Nweke, 1996).
The quality to be considered in the production of flour for human consumption are nutritional factors, mineral composition, chemical composition, absence of mycotoxins, heavy metals, and residual cyanogens (Asiru, 2004). Cassava flour has major potential as an additive to or substitute for other types of flours in private households and food industry. Although cassava has low nutritional value, yet remains an important stable food in tropical regions of Africa. Cassava can be used in private household to create a range of dishes, including pastries such as cookies, biscuits and rolls, doughnut, cakes, bread, flakes etc. Cassava flour is less expensive than imported wheat flour, enabling household users to occasionally surprise the family with some cookies or a cake at no extra cost (Asiru, 2004). However, cassava flour contains a list of mineral elements in trace amount and are essential to the body but may also contain a number of heavy metals that are absorbed from the soil. Heavy metals are not good for the body; they could be very toxic when consumed in large quantity (Motto, 1990).
Heavy metals, when present even at low concentrations in foods, have the capability to cause human health problems. Information about the dietary intake of such metals is important to assess risks to consumers. Dietary intake could account for some fractions of the toxic metals found in the blood and urine of many Nigerians (Babalola *et al*., 2007)

Food safety is an important aspect of a nation's economic stability and due to previous reports on the degree of pollution of some other food items (Adekunle *et al.*, 2004 and Adekunle *et al.*, 2009).
This study, therefore aimed at assessing some heavy metals concentration in cassava flour sold in three major markets in Igboora, Oyo State South-West Nigeria as a case study.

MATERIALS

Cassava
Metals e.g. Cu, Cd, As, Ni, Pb, Cr and Zn
HNO3
HClO3
Distilled water
Atomic Absorption Spectrophotometer

METHODS

Sample Collection

Cassava flour samples were obtained from three major markets (Towobowo, Oja-Oba and Onilado) in Igboora, Oyo State and grouped into three. Samples were stored in transparent polythene bags and transported to the laboratory for analysis.

Sample preparation

Quartering was carried out on the samples after proper mixing to obtain composite samples. Sub-samples (1 kg, each) were taken at random from the composite sample (15 kg) and were processed for analysis by wet-ashing method. The samples were oven dried at 60 °C for 24 h.

Heavy metals determination

The dried samples were powdered in a mixer grinder without overheating the sample. 0.5 g each of dried samples was digested with HNO_3 and $HClO_4$ in a 5:1 ratio until a transparent solution was obtained. The digests were filtered and diluted to 25 ml with distilled water using analytical reagent grade chemicals. Atomic Absorption Spectrophotometer was used to determine mineral elements (Cu, Cd, As, Ni, Pb, Mn, Cr and Zn) concentration.

RESULTS AND DISCUSSION

The result of the analysis of the levels of the heavy metals and their levels found in the samples of Cassava flour from three markets in Igboora, Oyo State are presented in Table 1. From the results obtained for Ni in this study, the cassava samples from the three major markets (Towobowo, Oja Onilado and Oja Oba) had concentration rates of (0.36 mg/kg, 0.071 mg/kg and 0.052 mg/kg) respectively, while samples from Towobowo gave higher concentrations as shown in Table 1. Ni activates some enzymes function in the body but its toxicity at higher level has its effect in the blood and kidney. All the samples that were analyzed for Zn were below the acceptable limit of 50.0 mg/kg. Zn levels were from 2.75 mg/kg to 4.55 mg/kg. Zn is an essential trace element for humans; it is vital for many biological functions and plays a crucial role in more than 300 enzymes in the human body. Zn is needed for growth and plays a vital role in fertility. In males, Zn protects the prostate gland from infection (prostates) and ultimate enlargement (prostatic hypertrophy). Zn deficiency in the body is worse than its toxicity. Concentration levels of Cu in the samples are (0.26 mg/kg, 0.06 mg/kg and 0.34 mg/kg) Copper is essential in the body for good health. It helps prevent inflammation in arthritis and similar diseases, but in high doses, it can cause anemia, liver disease and kidney damage. The results show that Pb concentrations for cassava flour samples are 0.14 mg/kg, 0.28 mg/kg and 0.424 mg/kg. These samples except for those samples from Towobowo slightly exceeded WHO maximum acceptable limit of 0.2 mg/kg. Therefore, there could be risk of Pb poisoning from cassava flour samples from Onilado and Oja Oba markets, and it is well established that exposure to high levels of Pb may cause kidney damage leading to renal failure (Laura *et al*., 2009 and Colgan, 2003). Such concentration of Pb in cassava flour samples and other trace heavy metals will affect huge populations especially children (Wang *et al*., 2006 and Canfield *et al*., 2003) and all exposed adults (Saraiva *et al*., 2007). Pb is considered a potential carcinogen and is associated with etiology of a number of diseases especially cardiovascular diseases. All the samples analyzed for Cadmium and Arsenic fell detection limit. Cr concentration was detected at 0.001 mg/kg. Cadmium has no known biological functions. It interferes with some essential function of Zn, thereby inhibiting enzyme reactions and nutrient utilization. It catalyzes oxidation reactions, generating free-radical tissue damage (WHO, 1992)

Table 1: Concentration of heavy metals in Cassava flour from 3 different markets in Igboora

Elements	Site A	Site B	Site C
Cu mg/kg	0.26 $\pm$ 0.03	0.06 $\pm$ 0.03	0.34 $\pm$ 0.02
Ni mg/kg	0.36 $\pm$ 0.01	0.071 $\pm$ 0.01	0.052 $\pm$ 0.01
Pb mg/kg	0.14 $\pm$ 0.02	0.28 $\pm$ 0.01	0.424 $\pm$ 0.02
Cd mg/kg	BDL	BDL	BDL
Mn mg/kg	0.031 $\pm$ 0.03	0.021 $\pm$ 0.03	0.013 $\pm$ 0.02
As mg/kg	BDL	BDL	BDL
Cr mg/kg	0.001 $\pm$ 0.01	0.001 $\pm$ 0.01	BDL

Zn mg/kg	2.75 ± 0.02	4.55 ± 0.03	3.84 ± 0.01

Mean ± standard deviation, BDL = Below Detection Limit

Table 2: WHO Permissible limits of selected heavy metals

Elements	Quantity
Cu	10 mg/kg
Ni	0.5 mg/kg
Pb	0.2 mg/kg
Cd	0.05mg/kg
Mn	0.02 mg/kg
As	0.01 mg/kg
Cr	0.05 mg/kg
Zn	50 mg/kg

Trace metal level for metal concentration established by WHO (1982)

CONCLUSION AND RECOMMENDATION

The study revealed the presence of heavy metals in samples from the area of study and indicated slight pollution activities. The concentration of heavy metals in the cassava flour were within the WHO maximum acceptable limit for food except for lead whose values were slightly higher than the permissible limits in samples collected from Oja oba and Onilado markets. The observed findings calls for serious health concern as heavy metals are bio accumulative in human organs and tissues and can result in various diseases and disorders, when not properly controlled.

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EFFECTS OF HEAT ON MINERAL, PHYTOCHEMICALS, VITAMINS, AND ANTI-OXIDANT PROPERTIES OF WATER LEAF (*TALINUM TRIANGULARE)*

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ABSTRACT
Vegetables are valuable sources of affordable nutrients, especially in developing countries; processing before consumption (heat treatment or boiling) may have effect on these nutrients. This project determined the effect of heats on minerals composition of Talinum triangulare (water leaf). The research was carried out by treating Talinum triangulare, with heat at temperature of 70^{0}C and 80^{0}C and without heat (ambient) for control. Three samples were air dried and extracted with ethanol. Mineral, phytochemicals, vitamins and antioxidant properties analyzed were carried out with standard procedures. The result showed that as the heat increase the mineral, phytochemicals, vitamins and antioxidant properties decreases. Overall, this study demonstrated that heat has a marked effect on the mineral, phytochemical, vitamin and antioxidant content of Talinium trangulare. It was found that the sample's nutritional value was significantly reduced after being heated to 80 ºC for 5minutes, with large decreases seen in both vitamin and antioxidant content. Thus, this study suggests that caution should be exercised during food preparation to ensure that the sample's nutritive value is maximized.
Keywords: *Mineral, phytochemicals, vitamins, antioxidant heat, Talinum triangulare*

INTRODUCTION
The term vegetable is generally described as the edible plant part which may be regularly or culturally consumed raw or cooked as unsweetened spiced or salted. In African countries, various species of vegetables are widely eaten boiled. Some others (mainly fruit vegetables) are eaten raw. Different types of leafy vegetables have been part of human diets since pre-historic times. These vegetables are typically low in calories, low in fat, high in protein per calories, high in dietary fibre, high in some mineral substances such as K, Ca, Mg, Na while others may be present in trace amounts. They are very high in phytochemicals such as vitamin C, carotenoids, flavonoids and saponin (Ghias and Abdur, 2012).
Waterleaf is characterized as growth tolerant in various soil types, temperature and moisture levels, and grows well under shade. In some places in Nigeria, it is often considered to be a very common plant but only a few people in Sub-Saharan Africa recognize it as a potential vegetable (Schippers, 2000). The Yoruba call it "Gbure" whereas the Igbos call it "Magborodi" in Sierraleone, it is referred to as "Bologi" while in Cameroon it is called "Clok-Sup" (Schippers, 2000).
Talinum triangulare is an important low cost food containing low levels of fat and high levels of vitamin, mineral, fibre and some calories and protein (Oguntona, 2011; Bolaji *et al.*, 2008; Mepha *et al.*, 2007). Waterleaf has the cheapest and most abundant sources of protein (Fasuyi, 2006) and enhances flavor, taste, colour and aesthetic appeal to the diet (Mepha *et al.*, 2007). Consumption of this vegetable ensures the intake of various essential vitamins thus avoiding the problem of malnutrition. However, they contain anti-nutritional which reduce the bioavailability of some nutrients (Akindahunsi and Salawu, 2005).
Effect of heat has been identified as the one factor which has the greatest adverse effect on vegetable (*Talinum triangulare*) High temperature and prolonged heating time associated with conventional heaters often causes heat damage and adversely affect the texture, colour, flavor and nutritive value of waterleaf.
This study aims to investigate on the effects of heat on mineral composition, phytochemicals, vitamins, and anti-oxidant properties of water leaf (*talinum triangulare).*

MATERIALS AND METHODS

Study Area

This study was carried out in the research laboratory of Science Laboratory Technology, Oyo State, college of Agriculture and Technology (OYSCATECH), Igboora.

Sample Preparation

The fresh leaves of harvested water leaf were removed from the main stalk and were sorted to remove the bruised ones. The good shape leaves were thoroughly washed in water and drained using plastic sieves. The drained leaves were divided into three (3) equal portions of 260g each.

Drying of the Sample

The first portion was spread on a stainless stray and air dried at ambient temperature in a well ventilated room. The weight was measure at 24h intervals until a constant weight was reached.

Heat Treatment of the Sample

The second and third portions of the sample were boiled using 1,200mL of water at 70°C and 80°C respectively for 5minutes. This was thereafter spread on a foil paper followed by air drying at ambient temperature.

Determination of Mineral composition, phytochemicals, vitamins and anti-oxidant properties

The three portions of samples (untreated, heat threated (70^{0}C and 80^{0}C)) were used for determination of mineral composition, phytochemicals, vitamins (A, B_1, B_2, B_6, C and E), and anti-oxidant properties using the methods described by Maciej *et al.*, (2007)

The method of Artington (2005) was used to determine sodium and potassium contents of the dried waterleaf samples using flame photometry. The calcium, magnesium and iron contents were determined after wet digestion with a mixture of nitric, sulphuric and hydrochloric acids using Atomic Absorption Spectrophotometer (AAS ZA3000).

Tannin content was determined as described by Mensah, *et al.* (2008) and flavoniods, Phenols, alkaloids, steroids, terpeniods, saponnins contents were also determined with the methods of Oguntona (2001).

The methods described by Maciej*et al.*, (2007) was used for vitamin A, Nethaji *et al.* (2010) for Vitamin B1(Thiamine) and vitamin B_2 (Riboflavin), Ahmad (2012) for Vitamin B_6 (Pyridoxine), Bekele and Geleta, (2015) for Vitamin C and Sami *et al., (*2014) for Vitamin E.

DPPH radical scavenging activity

The scavenging effect on DPPH free radical was measured following the method described by (Shimada *et al.*, 2003) with some modifications. Sample solution (5ml and α-tocopherol methanolic solutions (positive control group) were added to 1ml of 1mm DPPH in methanolic solution. The mixture was shaken and left to stand for 30 minutes at room temperature. The absorbance rates of the resulting solution and the positive control group was measured at 517mm. The lower absorbance (ASN) represents a higher DDPH scavenging activity, which is expressed as (1-test sample absorbance 1 blank sample absorbance) *100%.

Ferrous ion chelating ability

This was carried out according to the method described by Decker and Welch (1990)

Trolox equivalent antioxidant capacity

The ABTS scavenging activity was determined using the trolox equivalent antioxidant capacity (TEAC) method described by Yeh and Yen (2003).

Measurement of No productions in mnc-cms

The measurement was done as described by Yang and Park, (2006).

RESULTS AND DISCUSSION

Table 1: Mineral element concentrations of *Talinum triangulare* ethanol extract

S/N	Mineral elements	Concentrations Room Temperature (Control)	Following Extractions at 70^{0}C	80^{0}C
1	Iron	30.90	30.20	28.60
2	Manganese	0.50	0.04	0.09
3	Zinc	10.60	10.10	9.60
4	Copper	16.40	16.00	16.00
5	Phosphorus	65.50	59.80	59.00
6	Calcium	65.50	59.80	59.00
7	Sodium	260.80	256.10	254.30
8	Lead	0.08	0.08	0.001
9	Potassium	186.50	130.20	126.30

Table 2: Phytochemicals composition of *Talinum triangulare* (Waterleaf) Extract.

S/N	Phytochemicals	Room Temperature (control) (Mg)	Heat treatment at 70^0C (Mg)	Heat treatment at 80^0C (Mg)
1	Tannins	1.14	1.11	1.01
2	Flavonoids	23.5	20.7	18.6
3	Terpenoids	1.60	1.41	1.22
4	Steroids	0.14	0.12	0.12
5	Phenols	30.60	28.10	28.20
6	Alkaloids	29.40	28.70	26.42
7	Saponnis	1.00	0.80	0.17

Table 3: Vitamin composition of *Talinum triangulare* (Waterleaf) Extract.

S/N	Vitamins	Room Temperature (control) (Mg)	Heat treatment at 70^0C (Mg)	Heat treatment at 80^0C (Mg)
1	**A**	0.82	0.043	0.064
2	**B_1**	9.61	9.07	8.26
3	**B_2**	2.98	1.97	1.26
4	**B_6**	14.50	10.16	10.01
5	**C**	29.50	28.00	26.70
6	**E**	10.21	9.76	8.26

Table 4: Antioxidant activities of *Talinum triangulare* ethanol extract at various treatments

S/N	SAMPLE %	DPPH RADICAL %	ABTS %	NO %	FRAP %	OH %
1	Control	100.16	98.70	30.10	50.40	76.10
2	At 70^0C	125.70	100.10	49.40	64.80	89.20
3	At 80^0C	146.30	130.90	50.30	69.10	100.30
4	Catectin	86.00	78.50	25.40	47.30	50.60

KEY:
DPPH - 1.1 Diphenyl picryl hydroxyl
ABTS - 1.1 Azino ethyl benzothiazoline sulfonic acid
NO - Nitric acid
FRAP- Ferric ion reducing antioxidant power
OH- Hydroxyl ion

The results of the mineral contents of ethanol extract of *Talinum triangulare* are presented in Table1. It can be observed that heat treatment significantly affected the mineral element content of the *Talinum triangulare* ethanol extract. The mineral elements examined were iron, manganese, zinc, copper, phosphorus, calcium, sodium, lead and potassium.
The mineral elements compositions in the extracts were appreciably high in mineral content with the extract without heat having the highest values. The sodium content in the extract ranged from (260.80mg/L – 254.30mg/L), potassium (186.50mg/L – 126.30mg/L), calcium (65.50 – 59.0mg/L), phosphorus (65.50mg/L – 59.0mg/L), iron (30.90 – 28.60mg/L), copper (16.40 – 16.00mg/L), zinc (10.60mg/L – 9.60mg/L), manganese (0.5 – 0.09mg/L) and lead (0.08mg/L – 0.001mg/L). These ranges were from the extracts with and without heat treatments. This result is in accordance with the findings of Aletor and Adeogun (2004) who reported that mineral element could be made available in considerable amount by destroying the anti-nutritional factors which inhibit the mineral elements product in the food during drying, soaking and cooking processes.

The findings of this research are also in close agreement with many findings such as Asaolu *et al.,* (2012) and Oladele and Aborisade (2009).
The *Talium triangulare* extract was highly rich in the mineral element content, which indicates that the *Talinum triangulare* is a good source of mineral element need for the growth of plant and animals. The extract without heat treatment had the highest value compared to the heat treated extract (70^0C and 80^0C). The heat treatments significantly affected the mineral composition of *Talinum triangulare* and increase in the temperature caused a decrease in the mineral composition.

There were decreases in the concentration of phytochemicals as the temperature of the treatment increases as showed in table 2.

The highest values was observed with the phenols (28.20 - 30.6%) followed by alkaloid (26.42-29.40%), flavonoids (18.60-23.50%), terpenoids (1.22-1.60%), tannins (1.01-1.14%), saponnins (0.17-1.00%) and steroids (0.12-0.14%) being the least.

There was a decrease in the concentration of vitamins as the temperature of the treatment increased for vitamins B_1, B_2, B_6, C and E in the extract, except for vitamin A. VitaminB_1 ranged from (9.61 – 8.26mg/100g), Vitamin B_2 ranged from (2.98 – 1.26mg/100g), vitamin B_6 ranged from (14.57 – 10.01mg/100g), Vitamin C ranged from (29 – 50 – 26.70mg/100g) and Vitamin E ranged from (10.21mg/100g – 8.2mg/100g). The sample without application of heat had the highest value, while the temperature at 80^0C treatment had the lowest concentration of vitamins. The reduction in the vitamin concentration is as a result of sample been exposed to heat treatment. This is agreement with study of Negi and Roy (2000) who also demonstrated a loss of vitamins in green leafy vegetables which is a function of processing method such as temperature. The decrease is attributed to the thermo sensitive, labile and hydro soluble nature of vitamins which easily leached into heating medium.

The Vitamin C is a water soluble vitamin that easily dissolves in water. This simply implies that water can be used to dissolute the water soluble vitamins. The heat applied aided the dissolution of the vitamins due to the ability of temperature as factor affecting rate of chemical reactions.

DPPH activity ranged from (36.00-14.63) ug/ml with the highest value observed in *Talinum triangulare* extracts treated at 80°C. This indicated that scavenging of radicals was reduced at 70°C and 80^0C which is in agreement with the work reported by (Gruptal and Prakash, 2009). Also, the result is similar to the values obtained from (Kuyanya, *et al.*, 2011).

ABTS antioxidant activity obtained for the water leaf of the sample ranged (78.5-130.9) ug/ml with the catchin had most potency than treated sample. The next potent sample is the control sample in the antioxidative potential to scavenging the free radicals. The value for the treated sample was much higher than the one obtained for the effect of the beat on the Talinum. The values are also lower than the values obtained for two varieties of Talinum (Ezckwe, *et al*, 2002) (16.90 mmol TE/100g) and Fontem, (2001) (67.00 mmol TE/100g).

Nitric oxide radical (25.4-50.3) ug/ml indicating that the most potent antioxidant was Catechin Next to the Catechin was control sample and 70°C and 80°C respectively. This values are the pointer that the control sample are potent than the other treated samples in having the ability to scavenge the free radicals produced by Nitric oxide. This implies that the control sample have the bioactive compounds that are responsible for antioxidant product.

The value of FRAP in this study ranged from (47.3-69.1ug/ml). This is also showed that the control sample is having the ability to possess antioxidant properties than the heat treatment samples which are next to the Catechin (Standard antioxidant).

Hydroxyl free redicals ranged from (50.6-100.3ug/ml) shows similar trend exhibited by free radicals. Variation in the antioxidant activities are to be expected due to the heat treatment (Tenny, *et al.*, 2005).

The reduction level of vitamin C also shows that the antioxidant activities of the vegetable decreases as the temperature increases because vitamin C is a strong antioxidant agents (Button, 2004). Vitamin E is an antioxidant that protects body tissue from damage caused by free radicals. The vitamin E is a fat soluble vitamin. The result from this study indicates that as the temperature increase, the vitamin E level in the sample decreases from temperature at 70^0C and 80^0C. There was high level of vitamin E in the sample without heat (control) than the heat treated samples. (Guyton and Hall, 2006).

CONCLUSION AND RECOMMENDATION

The traditional preparation of *Talinium trangulare* involves the application of heat. The effects of preparation using heat on the nutritional composition and antioxidant properties of *Talinium trangulare* studied showed that the application of heat decreased the content of minerals, phytochemicals, vitamins, and antioxidant properties of *Talinium trangulare*. The antioxidant properties of the plant were shown to also decrease significantly at high heat temperatures. This study found that the application of heat to *Talinium trangulare* decreased its nutritional composition and antioxidant properties, suggesting that the traditional preparation method of the plant at high temperature could hinder its overall nutritional quality.

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ANALYSIS OF PROFITABILITY OF GARI PROCESSING IN ANAMBRA STATE, NIGERIA

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PROCEEDINGS OF THE
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ABSTRACT
Analysis of profitability of gari processing in Anambra State, Nigeria was studied. Primary data were obtained from 120 respondents using questionnaire and oral interview. Percentages responses and gross margin analysis were used to analyze the data. Gari processing was profitable in the study area with net farm income of N39,300. Also, the major constraints to gari processing were poor access to credit, high labour cost and high cost of cassava roots. The need to enhance the processors' access to credit facility, labour saving devices and availability of cassava roots at subsidized costs were recommended.
Keywords: *Analysis, profitability, Gari processing Anambra State, Nigeria.*

INTRODUCTION
Cassava is the most widely available source of carbohydrates and dietary energy in Africa (Food Agriculture Organization Statistics (FAOTSAT, 2018). Gari, a derivative of cassava as asserted by Ibekwe, Chikezie, Obasi, Eze and Henri- Ukoha, (2012) has features, included creamy-white or yellow (if fortified with red palm oil) granular flour with a slightly fermented flavour and a slightly sour taste made from fermented gelatinized fresh cassava tubers. FAOSAT (2018) reported that gari constitutes more than 75% of cassava derivatives produced in Africa inform of most consumed and trade off. As a result, according to Oladipe (2011) the price of gari is often a reliable indication of the demand and supply of cassava.
The wide acceptability of the cassava derivative in cassava producing area by both rural and urban dwellers according to FAOSAT, (2018) could be ascribed to its relatively long shelf life, ease of preparation for consumption and cheaper than other carbohydrate sources, especially rice and maize. Nevertheless, gari can be consumed with a variety of additives such as sugar, groundnut, fish, meat and stew (Oladipe, 2011).
In the last decades, the prices of gari has been on decline in Nigeria, South East, Nigeria in particular and many processors are opting out of the business, for more lucrative enterprises. The low production and productivity of gari processing can be related to high cost of labour, high transaction cost, poor transportation, irregular and seasonal supply of cassava roots, high cost of energy sources, scanty of cassava processing machines and among others (Ewebiyi,Ikotun and Olayemi, 2020). Therefore, it becomes paramount to determine the factors that affect processors' performance in processing and their productivity in terms of profit accruing from the gari processing in the study area
The specific objectives of the study are to describe the socioeconomic characteristics of the processors, estimate the profitability of gari processing and identify constraints to gari processing in the study area.

MATERIAL AND METHODS
Anambra State lies between latitudes $06^0 45'$and $05^o 42'$ North of Equator and longitudes $7^0 5'$ and $06^0 05'$ East of Greenwich Meridian. It occupies a total land area of 7,340square kilometer with a population of approximately 3,756.104 million people (NPC, 2006).A total of 120 processors were interviewed and used for the study. Structured questionnaire and oral interview were used to collect the data. Percentage responses and Gross margin analysis were used to capture the objectives of the study.

Model Specification

Gross margin (GM) analysis,

It is the difference between the total revenue (TR) and the total variable cost (TVC)

$G.M. = TR - TVC$ ………………………………(1)

NFI = TR – TFC………………………………..(2)
GM = Gross margin (₦), NFI = Net farm income (₦), P1 = Market (unit) price of gari (₦), Q = Quantity of gari (kg), ri = Unit price of the variable input (kg), xi = quantity of the variable input (kg), K = Annual fixed cost (depreciation) (₦), i = 1
2 3 …….. n , j = 1 2 3 …….. m

RESULTS AND DISCUSSION.

Table 1; -Mean Socioeconomic Statistics of Gari Processors in Anambra State, Nigeria.

Variable	Mean	Std Deviation
Age (Year)	36	2.112
Educational Level(Years)	4.6	0.225
Household Size(No)	4.2	0.015
Processing Experience (Years)	10.4	0.007
Membership of Organization(No)	2.4	0.019

Source; Field Survey, 2021

The mean socioeconomic statistics of gari processors in Anambra State, Nigeria is shown in table 1.On the average, a typical gari processor was 36 years This could infer most of the processors of gari are innovative, motivational and adoptive individuals, hence could improve their welfare (Ibekwe; *et al;*2012). Similarly, an average gari processor had educational level of 4.6 years. People with high formal education tends to have more access to information on given technology in order to boost their adoptability of such innovation than those that are less or not educated (Adeoye-Agomoh, Ume and Chukwu; 2022). As well, the average household size of the sampled processors was 4.2 persons. Literatures show that the impact of household size to gari processing depends on the magnitude, age structure and available farm labour among members (Onadipe,2011). Furthermore, an average gari processor had processing experience of 10.4years. Processors with long years of processing experiences have more propensity of setting realistic goal (Ume; *et al;*-2020). Additionally, an average processors belonged to 2.4 organizations such as cooperatives, farmer club, social club etc. Organization such as cooperative enables members to have access to information on improved innovations, credit and material inputs of the technology, in order to boost the adoption of such technology(Ewebiyi,*et al;* 2020)

Table 2 Costs and return of processing 1000kg of cassava roots to gari

Item	Unit	Price/ unit	Quantity	Value
Revenue				
Gari	Kg	140	600	84,000
Total Revenue				84,000
Variable Cost				
Inputs				
Cassava tuber	Kg	30	1000	30,000.
Firewood				4000
Palm oil				300
Sub Total				34,300
Labour for gari processing				5000
Transportation				400
Total Variable Cost				39,700
Fixed Cost				
Depreciation				5,000
Total Fixed Cost				5,000
Total Cost				44,700
Net return				39300

Source; Field Survey, 2022
.
To estimate the net revenue for the production of gari using 1000kg of cassava tubers, net margin analysis was used. The result showed that after processing 1000kg of cassava tubers, 600kg of gari was produced. A kilogram was sold at N140 for 600 kg and this gave an estimated total revenue of N84, 200. The total cost is made of total variable cost and total fixed cost. The total cost of processing 1000kg of cassava roots to produce 600kg of gari was N46, 800. The cost of inputs was N34, 300 which accounted about73.29% of the total cost, .Labour cost was N5000:00, which is equal to 10.68%· of the total cost; transportation .cost was N400 which· is about 0.856.% of the ·total cost while the total fixed cost was about N5000 and about 10.68% of the total cost. The high contribution of cassava input in gari processing could be related to recent economic recession in the country as farmers sell this resource (cassava roots) at exorbitant prices to keep afloat (Samuel, 2017). Net returns per 1000kg of cassava

tubers processed to gari ,defined as the difference between total revenue and total cost· per 1000kg roots was estimated at N39,300 in the survey year.

Table 3Constraints to gari processing

Variable	Frequency	Percentage
Poor access to credit	100	83.33
High labour cost	92	76.67
Scarcity of milling machines,	78	65
High cost of cassava roots	110	91.67
Bad road	54	45

*Multiple Responses
Source; Field Survey, 2022

Most (91.67%) of the respondents reported high cost of cassava roots. The reason for high cost of cassava inputs could be related to different uses of the cassava roots and during the period of the year (Cassava tuber is expensive during dry season; December – March , owning to the fact that cassava roots are difficult to harvest due to hard soil) (Ume, *et al;* 2020). The least (45%), was bad road. This could be associated with many both feeder and major roads connecting urban markets are high deplorable with few vehicles plying there, at very exorbitant prices (FAOSAT, 2018, Adeoye-Agomoh, *et al;* 2022).

CONCLUSION AND RECOMMENDATION

Gari processing is profitable in the study area. The constraints to gari processing were poor access to credit, high labour cost, scarcity of milling machines, high cost of cassava roots and bad road. Based on the results, the following recommendations were made. The need to enhance processors' access to credit facility at reduced interest rate, ensure availability of roots all year round by mechanizing roots harvesting and need to renovate bad roads in the study area for to and fro of gari processing inputs and output to markets in urban areas

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ECONOMIC LOSSES OF STORED PADDY RICE IN BENUE STATE, NIGERIA: ASSESSMENT OF MAGNITUDE AND DETERMINANTS

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ABSTRACT
One of the major problem of agricultural products is the post-harvest losses at various stages resulting to economic and quality deterioration and losses. The study assessed the economic losses of stored paddy rice in Benue State, Nigeria. Data for the study were collected from 246 rice farmers selected from 12 communities and 6 Local Government Areas (LGAs) using multistage sampling technique. The collected data were analyzed using descriptive statistics and multiple regression model. The result showed that on average, rice farmers in the study area lost ₦2090 per 100kg of stored paddy rice. The multiple regression analysis revealed that age level of education (β=0.63), farming experience (β=0.44), annual income (β=0.60), household size (β=0.26), and involvement in off-farm business (β= -0.25) influenced economic losses of stored paddy rice in the study area. The study recommended that the design and implementation of policies and programmes targeted at minimizing storage losses of paddy rice should take into consideration the characteristics of the rice farmers. In addition, Government and Non-governmental organizations should aid farmers through their cooperatives to acquire improved and cost effective drying equipment; and farmers' cooperatives in the study area should come together and build a standard storage facility.
Keywords: *Economic losses, storage, paddy rice, magnitude, determinants*

INTRODUCTION
In spite of the numerous policies and programmes put forward by various administrations in Nigeria over the years to make the country self-sufficient in rice production, postharvest storage losses have continued to erode the gains from such efforts. In a report by Danbaba *et al*. (2019), 10-30% of paddy rice produced in Nigeria does not reach the final consumers due to inefficient postharvest management practices. This has resulted in deficit between the domestic demand for rice and domestic production which as at 2022 was 2.00 million metric tonnes (Ibirogba, 2022) and projected to increase to 4.5million metric tonnes by 2029 (Olowa, 2020).
In order to find a lasting solution to the incidence of post-harvest losses, many empirical researches have surfaced. While these studies have contributed to our understanding of the post-harvest losses menace, information on the economic losses of stored grains especially in rice production is still scanty. Thus, the main objective of this study was to assess the magnitude and determinants of economic losses of stored paddy rice in Benue State, Nigeria. Specifically, the study aimed to: estimate the magnitude of economic losses of stored paddy rice; and identify and analyse the determinants of the economic losses. The null hypothesis tested was that the socioeconomic characteristics of rice farmers do not significantly influence the magnitude of economic losses of stored paddy rice in the study area.

METHODOLOGY
The Study Area
The study was conducted in Benue State, which lies within the lower river Benue trough in the middle belt region of Nigeria. It geographical coordinates are Longitude 7°47′ and 10°0′ East. Latitude 6°25′ and 8°8′ North and occupies a land mass of 34,059 km^2. The State is one of the North Central States in Nigeria with a population of about 6,141,300 (Brinkhoff, 2022). Farmers who engaged in arable crop production like rice, yam, cassava, sweet potato, maize, vegetables, soybeans as well as livestock like poultry, goat, sheep, piggery, cattle and fish abound in the State.

Population of the Study

The population of the study consisted of the 210,839 registered rice farmers in Logo, Kwande, Guma, Makurdi, Agatu, and Apa Local Government Areas of Benue State obtained from Benue State Agricultural and Rural Development (BNARDA) in 2021. These LGAs were chosen because of their vast production of rice.

Sampling Technique and Data Collection

Multi-stage sampling technique was employed to select a sample of 246 rice farmers. The data for the study were collected using structured questionnaire.

Analytical Techniques

The data collected were subjected to descriptive and econometric analyses. Descriptive statistics such as mean, percentage, and frequency table were used to describe the economic losses of stored paddy rice while multiple regression model was used to identify and analyse the determinants of economic losses.

The four functional forms: linear, exponential, semi-log, and double-log were tried. The double-log was selected as the lead equation based on the magnitude of R^2, the *a priori* expectation, and number of significant coefficients of the independent variables.

The four functional forms were specified as follows:

Linear:

$$Y= a_0+b_1X_1+b_2X_2+b_3X_3+b_4X_4+b_5X_5+b_6X_6+b_7X_7+b_8X_8+b_9X_9+b_{10}X_{10}+b_{11}X_{11}+ \varepsilon_i \quad (1)$$

Exponential:

$$\ln Y = a_0+b_1X_1+b_2X_2+b_3X_3+b_4X_4+b_5X_5+b_6X_6+b_7X_7+b_8X_8+b_9X_9+b_{10}X_{10}+ b_{11}X_{11}+\varepsilon_i \quad (2)$$

Semi-log:

$$Y= a_0+b_1X_1+\ln b_2X_2+b_3X_3+\ln b_4X_4+\ln b_5X_5+\ln b_6X_6+b_7X_7+\ln b_8X_8+b_9X_9+\ln b_{10}X_{10}+b_{11}X_{11}+\varepsilon_i \quad (3)$$

Double-log:

$$\ln Y= a_0+b_1X_1+\ln b_2X_2+b_3X_3+\ln b_4X_4+\ln b_5X_5+\ln b_6X_6+b_7X_7+\ln b_8X_8+b_9X_9+\ln b_{10}X_{10}+b_{11}X_{11}+\varepsilon_i \quad (4)$$

Where: Y = Economic losses of stored paddy rice (Naira); a_0 = Constant; b_1-b_{11} = Regression coefficients; $\ln$ = Natural logarithm; X_1 = Sex (male=1, female=0); X_2 = Age (years); X_3 = Marital Status (single=1, married=0); X_4 = Farm size (Ha); X_5 = Level of education (years); X_6 = Household size (number of persons); X_7= Cooperative Membership (member=1, Non-member=0); X_8 = Farming Experience (years); X_9 = Extension Contact (had contact=1, had no contact=0); X_{10} = Annual Income (Naira); X_{11} = Off-farm business (involved =1, not involve = 0); and ε_i= Error term

The *a priori* expectation was that the coefficient of sex, farm size, marital status, household size, and off-farm business involvement would be positive while those of age, level of education, farming experience, membership of cooperative, extension contact, and annual income would be negative.

RESULTS AND DISCUSSION

Economic Losses of Stored Paddy Rice

The distribution of rice farmers by economic losses of stored paddy rice is presented in Table 1.

The result shows that majority (66.7%) of the rice farmers in the study area recorded between ₦2000 and ₦12,000 economic losses per 100kg of stored paddy rice. On average, the rice farmers recorded ₦2090 economic losses per 100kg of stored paddy rice.

Table1: Distribution of rice farmers by economic losses of stored paddy rice (n=246)

Variable	Frequency	Percentage	Mean
Economic losses (₦'000/100kg)			₦2090/100kg
≤1	80	32.5	
2-12	164	66.7	
13-23	1	0.4	
≥24	1	0.4	

Source: Field survey data, 2022

Socio-economic Determinants of Post-Harvest Storage Losses Intensity

The socio-economic determinants of economic losses of stored paddy rice are presented in Table 2. The result in Table 2 shows that 58.95% of the variation in the level of economic losses of stored paddy rice was explained by the independent variable included in the model as shown by the R^2. The F-value (24.15) as shown in Table 2 was significant at 1% level. Thus, the null hypothesis that socio-economic factors do not significantly influence economic losses of stored paddy rice in the study area was rejected.

Table 2: Determinants of Economic Losses of Stored Paddy Rice

Variable	Linear	Exponential	Semi-Log	Double-Log†
Sex	164591.7^{NS}	0.0093^{NS}	-180387.7^{NS}	0.075^{NS}
	(1197500)	(0.11)	(1282303)	(0.10)
Age	-168040*	-0.0046^{NS}	-10400000**	-0.046^{NS}
	(98766.35)	(0.0087)	(4611469)	(0.36)
Marital status	1435767^{NS}	-0.083^{NS}	2295570^{NS}	0.11^{NS}
	(1655063)	(0.15)	(1804304)	(0.14)
Farm size	703937.60***	0.040**	3772663**	0.011^{NS}
	(179194.60)	(0.015)	(1518681)	(0.12)
Level of education	304477.90**	0.043***	4093963**	0.63***
	(153584.90)	(0.013)	(1927354)	(0.15)
Household size	604606.40***	0.048***	3006565*	0.26*
	(173329.60)	(0.015)	(1734574)	(0.14)
Membership of cooperative	330302.20^{NS}	-0.060^{NS}	195380.80^{NS}	-0.072^{NS}
	(1225800)	(0.11)	(1270992)	(0.10)
Farming experience	181365.50*	0.026***	3666194*	0.44***
	(104691.60)	(0.0092)	(2070958)	(0.16)
Extension contact	-1573792^{NS}	-0.058^{NS}	-1534465^{NS}	-0.094^{NS}
	(1299100)	(0.12)	(1407641)	(0.11)
Annual income	1.16**	-0.00000018***	3367863***	0.60***
	(0.56)	(0.0000000465)	(1286376)	(0.10)
Off-farm business involvement	-1615760^{NS}	-0.19^{NS}	-910141.40^{NS}	-0.25*
	(1555430)	(0.13)	(1724811)	(0.13)
Constant	-3884119^{NS}	13.27***	-33300000*	4.85***
	(3778191)	(0.32)	(18900000)	(1.44)
R^2	0.3192	0.5244	0.2534	0.5895
Adjusted R^2	0.2872	0.4985	0.2153	0.5651
F-value	9.97***	20.25***	6.66***	24.15***

Source: Field Survey data, 2022. Values in bracket are standard error, ***= sig @ 1%, ** =sig @ 5%, * = sig @ 10%, NS = not significant; †= lead equation.

Analysis of the result in Table 2 shows that the coefficient of level of education, farming experience, and annual income were significant at 1% level positively related to economic losses of stored paddy rice. Farmers who are well-educated and experienced including those with higher annual income are expected to experience minimal post-harvest storage losses as their attributes favour adoption of modern post-harvest technologies that prevent losses of rice along the post-harvest chain. However, farmers with these favourable adoption attributes that their economic losses increase are those without access to the necessary equipment and infrastructures that minimizes post-harvest storage losses. According to Okadonye *et al*. (2021), if farmers are provided with adequate equipment and necessary infrastructures, they tend to experience minimal post-harvest losses.

The coefficient of household size was significant at 10% and positively related to economic losses of stored paddy rice. Farmers with more household members would most likely employ family labour to save cost. However, often time, family labour are less skilled in good storage practices thus resulting in high post-harvest losses. This finding corroborates Babatunde *et al*. (2019) who observed a positive relationship between household size and post-harvest losses among rice farmers in Kwara State, Nigeria.

The coefficient of off-farm business involvement was significant at 10% and negatively related to economic losses of stored paddy rice. This is expected owing to the increase in income that comes with such involvement and thus, enhancing the farmers capacity to adopt technologies that minimizes storage losses. This finding agrees with Mutungi *et al*. (2003) who observed off-farm income as one of the determinants of adoption of improved post-harvest technologies among maize farming households in Tanzania.

CONCLUSION AND RECOMMENDATIONS

On average, rice farmers in the study area recorded ₦2,090 economic losses per 100kg of stored paddy rice. Evidence from the study also shows that the socio-economic characteristics of rice farmers in the study area influence the economic losses of stored paddy rice. The variable off-farm business involvement decreases economic losses stored paddy rice by 0.25%, while educational level, farming experience, annual income, and household size increases it by 0.63%, 0.44%, 0.60%, and 0.26% respectively.

Based on the findings of the study, the following were recommended:

- The design and implementation of policies and programmes targeted at minimizing storage losses of paddy rice should take into consideration the characteristics of the rice farmers especially their educational level, farming experience, annual income, household size, and off-farm activities involvement.

- Government and Non-governmental organizations should aid farmers through their cooperatives to acquire improved drying equipment, from simple tarpaulins and covers, to grain drying equipment and shelters that protect from the rain.
- Farmers' cooperatives in the study area should come together and build a standard storage facility with modern facilities as this will aid famers who lack the means to acquire farm storage technologies and thus enabling them to safely store their grains.

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CASSAVA PROCESSORS DECISION ON THE ADOPTION OF ENVIRONMENTAL FREE TECHNOLOGIES IN OTUKPO LOCAL GOVERNMENT AREA (LGA) OF BENUE STATE, NIGERIA

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ABSTRACT
Decision making on the adoption of new technologies towards promoting advancement of development is key to sustainable development. The study assessed cassava processors decision on the adoption of environmental free technologies in Otukpo Local Government Area of Benue State, Nigeria. Multi-stage sampling technique was adopted for the study. Primary data were collected and used for the study. The data were collected through administering questionnaires directly to the respondents. Data for the study were analyzed using both descriptive and inferential statistics. The study found that majority (95.8%) of the cassava processors used mechanical energy for processing cassava, it was further revealed that majority (85.0%) of the cassava processors practiced land filling technology in processing cassava. The logistic regression results on the factors affecting processors decision on adoption of environmental free technologies revealed that the coefficient of gender (-1.242) and processing experience (0.208) were the socioeconomic factors affecting Cassava mash soft dough (akpu/fufu) processors. It was also revealed that age of the processors (0.077), household size (-0.243) and off-farm income (0.000) were the socioeconomic factors affecting garri processors decision on adoption of environmental free technologies, while household size (0.347) and off-farm income (0.000) were the factors affecting starch processors decision on adoption of environmental free technologies. The study therefore recommended that cassava processing facilities should be located very far from residential areas, important streams, rivers or municipal drinking water sources to avoid possible pollution of the environment and water bodies, loans and grants should be made available to cassava processors in order to be invested in other income generating activities since off-farm income of processors is positively related with adoption of innovation. In addition, processors should be educated on the best technology to adopt in the processing of cassava to eliminate environmental pollution.

Keywords: *Environmental Free Technologies, Adoption, Cassava, Processor*

INTRODUCTION
Cassava (*Manihot esculenta* Crantz) is a very important food crop that is capable of providing food security. Cassava roots can be converted through processing into enough food. Machine application for cassava roots processing has helped greatly to add value, leading to profit making and provision of food (Ezike, Sennuga and Afolayan, 2022). However, the growing use of these cassava processing technologies and the clusters of the numerous of small scale cassava processing units is causing environmental and human health concern, including other urban and rural areas of the developing countries (Nnadozie, 2015). For instance, the water discharged from a cassava processing factory is acidic with a high organic matter content (soluble carbohydrates and proteins) and suspended solids (lipids and non-soluble carbohydrates - starch or cellulose fibers) is capable of emanating foul odour and unappealing sight and breeding ground for mosquitoes and houseflies especially if the wastes are untreated before discharging them into stagnant ditches and gutters (Ehiagbonare, *et al*., 2009). Land fill technology is a system of trash and garbage disposal in which the waste is buried between layers of earth to build up low-lying land.

METHODOLOGY

Study Area

The study was carried out in Otukpo Local Government Area of Benue State, Nigeria. It is located in the North-central geopolitical zone of Nigeria and has its headquarters in the town of Otukpo. The study area is bordered by Gwer-West, Gwer-East, Apa, Ohimini, Ado of Benue State, Ankpa and Olamaboro LGAs of Kogi State. The Local Government has a population of 266, 411 people according to the National Population Commission (NPC 2006). The area is mostly inhabited by the Idoma people. Otukpo LGA is regarded as the capital of the Idoma Nation. It has an average temperature of 29^oC and is mostly characterized by grassy and flat topography, and with two distinct seasons, which are the dry, and rainy seasons with the total precipitation estimated at 1550mm of rainfall per annum. The area is widely renowned for its rich agricultural heritage with crops such as yam, maize, cassava, beniseed, soybeans, and millet grown in large quantities. A number of minerals such as kaolin are found in the LGA as well. Other important economic enterprises undertaken by the people include animal rearing, trade, and lumbering (Benue State Agricultural and Rural Development Authority, 2005).

Sample size and Sample Techniques

The study adopted a multi-stage sampling technique. First, a purposive sampling technique was used to select two (2) districts based on their high participation in cassava processing. The second stage involved a simple random selection of two communities from each selected districts. Finally, a proportion of 5% (0.05) was used to get the sample size from the sample frame of all the cassava processors; this gives every member of the population a fair chance of being selected. Thus, a total of 120 respondents were selected.

Data Collection and Data Analysis Techniques

Primary data were collected and used for the study. The data were collected through administering questionnaires directly to the respondents. Data for the study were analyzed using both descriptive and inferential statistics. Descriptive statistics such as frequencies, percentages and mean were used to identify environmental free technologies adopted by cassava processors, while logit regression was used to examine the factors affecting the processors' decision in adopting environmental free technologies.

Model Specification

Logit regression was employed to estimate the factors affecting adoption of improved technology by cassava processors in the study area. The logit function can be defined in its inverse logistic form as:

$$\text{Prob}(Y_i=1)=\text{Ln}\left(\frac{P_i}{1-P_i}\right)= \beta_0+ \beta_1X_{1i}+ \beta_2X_{2i}+ \beta_3X_{3i}+ \beta_4X_{4i}+ \beta_5X_{5i}+ \ldots\ldots \beta_{10}X_{10i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where, Y= technology adoption (1 adoption and 0 non adoption)

X_1=gender (male = 1 and female =0)

X_2=level of education of farmers (years)

X_3=age of the farmers (years)

X_4= processing experience (years)

X_5=size of household (number)

X_6=access to credit (1= access and 0=no access)

X_7=membership of cooperative (Yes = 1, No = 2)

X_8=off farm income (Naira)

X_9=extension contact (number of times)

X_{10}=marital status (1=married and 0=single)

β=estimated parameters, including the constant term (β_0).

RESULTS AND DISCUSSION

Technologies Adopted by Cassava Processors

Table 1 revealed the technologies adopted by cassava processor. The result revealed that majority (85.0%) of the cassava processors practiced land filling technology in processing cassava and it ranked 1st. It also revealed that 69.1% of the respondents (ranked 2nd) used open pit in processing cassava. Closely and ranking 3rd is heap method used by 68.3% of the respondents, while 67.5% of the respondents used modern fuel source and are ranked 4th. It is also revealed that 46.7% of the respondents used lagoon in cassava processing and this ranked 5th while few of the respondents (30.0%) wear protective clothing when processing cassava in the study area. The high percentage of the respondent using land filling and open pit methods are due to the fact that the products like chips, flour, garri amongst others are mostly displayed for sun drying during or after processing and the fermentation processes involved.

Table 1: Technologies Adopted by Cassava Processors

Variables	Frequency	Percentage	Rank
Heap	83	68.3	3rd
Open Pit	83	69.1	2nd
Wearing of Protective Clothing	36	30.0	6th

Modern Fuel Source	81	67.5	4th
Lagoon	56	46.7	5th
Land filling	10	85.0	1st

Source: Field Survey, 2022

Factors Affecting Processors Decision on the Adoption of Environmental Free Technologies

Table 2 shows the logistic regression results on the factors affecting processors decision on adoption of environmental free technologies. The result revealed that the coefficient of gender of the processors of the akpu/fufu was negative and significant at 5%. The negative sign could be related to decrease in an attitude of different gender in adoption of environmental free technologies. Furthermore, the coefficient of age of processors of garri and flour were positively significant at 10%. The positive sign of the age is stem from information and skilled acquired from years of observations and experimentations with various cassava-processing technologies aimed at curtailing significantly pollution of the environment. This study agrees with Nnadozie (2015) who posited that regular and long experimentation helps in adopting pollution free technologies.

Also, educational level of the chips processors was positive and significant at 5%. Educational attainment of individual enhances their receptiveness of processing innovation and efficient use of resources to avoid pollution of the environment. This finding is in line with Ume *et al.* (2020). The marital status of chips processors was positive and significant at 10% level of significance. Married couple may through sharing experience adopt a better way of processing cassava that will protect the environment from pollution. This study gives credence to Kolawole (2014) who posited that married respondents adopt more environmental friendly technologies.

Furthermore, the coefficient of household size of garri processors was negative and significant at 5%, this implies that increase in household size reduce adoption of environmental free technology. This may be due to the fact that large family often leads over exploitation of natural resource when the family members try to carter for their different needs. The household size of starch processors was positive and significant at 1%. This indicates that more household size in starch processing encourages adoption of environmental free technologies. This may be due to the fact that few households are involved in starch processing in the study area. This study gives credence to Ani *et al* (2019).

On the coefficient of processing experience, the fufu/akpu and chips processors have positive coefficient that is significant at 1% and 10% respectively. Processing experience enhance the cassava processors' ability of maximizing their outputs at a minimum cost, with high prudence of conserving the ecosystem, from possible environmental pollution as a result of their action. This is in line with the findings of Ume *et al.* (2020) who posited processors' years of experience correlates with efficiency and effectiveness in accomplishment of processing activities with minimal detriment to the environment.

The off-farm income of garri, starch and flour processors were positive and significant at 10%, 1% and 10% respectively. Off-farm income could be used by processors in acquiring material inputs, equipment and hiring labour in adopting environmental free technology thus minimizing toxicity of the ecosystem. This is in line Ume *et al.* (2020); Nnadozie (2015). Therefore, the null hypothesis that states, the socioeconomic characteristics of cassava processors have no influence on their adoption of environmental free technologies is hereby rejected.

Table 2. Logistics Regression on Factors Affecting Processors Decision on the Adoption of Environmental Free Technologies

Variables	Garri	Akpu/Fufu	Starch	Flour	Chips
Gender	-0.199(0.710)	-1.242(0.014**)	0.091(0.842)	-0.632(0.162)	-0.570(0.175)
Age of the Processor	0.077(0.099***)	-0.02(0.624)	-0.033(0.408)	0.074(0.051***)	0.030(0.380)
Educational Level	0.092(0.207)	0.002(0.975)	-0.049(0.397)	0.008(0.895)	0.127(0.022**)
Marital Status	-0.107(0.795)	0.315(0.412)	-0.473(0.168)	0.257(0.437)	-0.479(0.098***)
Household Size	-0.243(0.048**)	0.007(0.954)	0.347(0.002*)	-0.037(0.719)	-0.080(0.403)
Processing Experience	0.107(0.138)	0.208(0.006*)	-0.059(0.278)	0.006(0.903)	0.080(0.091***)
Membership of Cooperative	0.612(0.353)	0.331(0.589)	-0.148(0.784)	0.406(0.438)	-0.426(0.385)
Off-Farm Income	0.000(0.067***)	0.000(0.831)	0.000(0.003*)	0.000(0.057***)	0.000(0.439)
Extension Contact	-0.285(0.714)	0.663(0.368)	0.362(0.588)	-0.073(0.905)	-0.149(0.803)
Access To Credit	0.193(0.750)	0.104(0.847)	0.538(0.263)	-0.202(0.676)	0.282(0.533)
Constant	-2.105(0.213)	-1.007(0.533)	-0.157(0.916)	-2.448(0.091***)	-2.560(0.059***)

Log Likelihood	99.675	110.816	130.064	134.137	152.085

Source: Field Survey, 2023 * = significant at 1%, ** = significant at 5%, *** = significant at 10%

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DETERMINATION OF PHYTOCHEMICAL COMPOSITION OF METHANOL EXTRACT OF *SOLANUM MELOGENA* FRUIT OBTAINED IN IGBOORA, IBARAPA CENTRAL LOCAL GOVERNMENT, OYO STATE

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ABSTRACT
Solanum melogena possess nutritive and medicinal values that makes it a valuable addition to diets. This is basically because they contain reserve load of nutrients and phytochemical compositions such as saponin, phenol, flavonoids, tannins, carbohydrates and proteins among others. In this study, phytochemical composition of methanol extract of solanum melogena fruits were analysed quantitatively and qualitatively using standard analytical methods. The results showed the presence of alkaloids, flavonoids, tannin, terpenes, phenol, carbohydrate,protein, cardiac glycosides, coumarine and quinone but emodin and anthocyanin were absent. Quantitative analysis of the fruit were expressed in (mg/100g); total phenol (0.62), tannin (0.587), alkaloids (2.88), falvonoids (0.132) , saponin (6.60). The findings therefore suggest that the fruit is a good source of nutrient and phytochemical components required for medicine and food supplements.

Keywords**:** *Solanum melogena*, phytochemicals. Food supplements, analytical, compounds

INTRODUCTION
Natural products like leaves, stem, fruits and seeds are used traditionally as a source of medicine since time immemorial. More than 80% of the world's population in poor and less developed countries depends on the traditional phyto-constituents based medicines for the fulfillment of their primary health care needs along with some other uses (Rizvi and Mishra, 2013,). *Solanum melongena*, known as eggplant in English, Igba in Yoruba is a fruit that belongs to the nightshade family (Solanaceae) and is widely consumed worldwide. *Solanum meogena* is a good source of dietary fiber, vitamins, and minerals, including potassium, magnesium, and calcium. It is also rich in phytochemicals, such as phenolic compounds, flavonoids, and alkaloids. The fruits of *S. melogena* have a great dietetic value resulting from variable chemical composition. These fruits have low energy value (100 KJ per 100 g). These nutrients or bioactive compounds play important roles in satisfying human needs for energy, body building and other life processes; a deficiency may results in abnormalities (Adam *et al*., 2012). Previous studies have shown that the consumption of eggplant fruits help reduce the risk of chronic diseases such as cancer, cardiovascular disease, and diabetes (Kaplan and Ng, 2017). The presence of phenolic compounds such as flavonoids in the fruits of *S. melogena* makes them a good antioxidant for scavenging free radicals and inhibit lipid peroxidation (Gürbüz *et al*., 2018). There has been an increasing interest in therapeutic potentials of medicinal plants such as antioxidant in reducing free radical-induced tissue injury. Many vegetables, fruits, and other plant species are commercially exploited as antioxidants because of their phytochemical compositions (Koleva *et al*.,2002). Report have shown a lot of work on Phytochemical composition on the fruits of *S. melogena* extracted using methanol. The objective of this work is therefore to determine the phytochemical composition of the fruit of *S. melogena* using methanol to support the established literature facts or determine the deviation.

MATERIALS AND METHODS
Sample collection and preparation
Solanum melogena fruits were obtained from Towobowo market in Igboora. Plant identification and authentication was done at Department of Botany, University of Ibadan, Ibadan. The fruits were washed, sliced and air dried at the chemistry laboratory in the Department of Chemistry for two weeks. The dried fruits were later ground to powder with a grinder and packed into a 200 ml brown bottle and labeled with cello-tape

Preparation of the Methanol extracts

The dried powdered fruits were weighed (200 g) into white musilin cloth. The muslin cloth was tight firmly and then immersed into 500 ml methanol with frequent agitation (Ndukwe *et al*., 2015; Handa *et al*., 2008) for the extraction of phytochemicals present in tested fruits.The set up was left for twenty-four hours after which different chemical test was carried out on the extract.

Phytochemical Screening

The phytochemical analysis of the fruit was conducted according to the methods described by Yadav and Agrawala (2011). Quantitative phytochemical determination were carried out using Mythili *et al.* (2014) method.

RESULTS AND DISCUSSION

Table 1: Qualitative analysis of the phytochemical composition of methanol extract of *Solanum melogena* fruits

S/N	Phytochemicals	Relative Presence
1	Saponins	+ve
2	Tannins	+ve
3	Flavonoids	+ve
4	Steroids	+ve
5	Terpenoids	+ve
6	Coumarins	+ve
7	Emodins	-ve
8	Quinones	+ve
9	Anthocyanins	-ve
10	Alkaloids	+ve
11	Cardiac glycosides	+ve
12	Phenols	+ve
13	Chalcones	+ve
14	Di-terpenes	+ve
15	Proteins	+ve
16	Carbohydrates	+ve

Table 2: Quantitative analysis of the phytochemical composition of methanol extract of *Solanum melogena* fruit

Phytochemical	Concentration (mg/100g)
Total Phenolics	0.628±0.004
Tannins	0.587±0.004
Alkaloids	2.88±0.02
Flavonoids	0.132±0.003
Saponins	6.60±0.04

Table 1 showed the results of the preliminary phytochemical constituents of the methanol extract of the fruit of *Solanum melogena*. The results revealed the presence of phytochemicals (saponin, tannin, flavonoids, steroids terpenoids, coumarin, cardiac glycoside and chalcone) and nutritive nutrients (protein and Carbohydrates). Emodin and Anthocynin was however absent in the preliminary test. This result was in agreements with the work of Ossamulu *et al*. (2014), Agoreyo *et* al. (2012) and Tiwari and Mehta, (2009). The presence of these chemicals support the ethno medicinal uses of this plant.

Table 2 showed the percentage phytochemical composition of *Solanum melogena* fruit (mg/100 g). High saponin (6.6 mg/100 g) and alkaloids (2.88 mg/100 g) content with tannin support the wider uses of the plant for medicinal uses.The present of phenolic content make the plant to be useful as anti clotting agent, immune enhancer and hormone booster (Amakoha *et al*., 2002).

CONCLUSION

The results of the study revealed that methanol extract of *Solanum melogena* fruits contained phytochemicals such as alkaloids, flavonoids, tannins, phenol, terpenes and cardiac glycosides. The presence of these potential bioactive substances make the fruits to be a useful raw materials in the medical sector while its protein and carbohydrate composition make it useful as food supplements for growth of animals and humans.

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BIOFORTIFIED STAPLE FOODS: CHEMICAL COMPOSITION OF FLOURS, SENSORY EVALUATION AND ACCEPTABILITY STUDY OF BREADS PRODUCED FROM WHEAT AND ORANGE-FLESHED SWEET POTATO FLOUR

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ABSTRACT
The β-carotene-rich sweet potatoes (orange-fleshed sweet potatoes [OFSP]) are one of the bio-fortified novel staple crops and excellent source of energy and vitamins that has been contributing to the advancement of nutritional status. Consumption of OFSP is one of the dietary strategies adopted to attack the deficiency of Vitamin A in sub-Sahara Africa. This study investigated the chemical composition and organoleptic properties of breads produced from composite flours of wheat and OFSP. The OFSP tubers were processed into flour, which was used to substitute 25, 50 and 75% of wheat flour in breads. The breads were compared with 100% wheat flour bread (control) for the nutrients composition and sensory properties. The results showed that addition of OFSP flour to wheat flour reduced the protein, carbohydrate and fat contents from 11.92% in the control to 8.75% in the blend containing 75% OFSP flour, 75.54 to 74.40% and 1.74 to 1.22%, respectively, while total ash, fiber and β-carotene contents increased from 0.93 to 2.22%; 0.24 to 4.55% and 0.211 to 7.89 mg/100g, respectively. The texture, taste and colour of all the breads were acceptable to the panellists, with the bread produced from 75% and 25% OFSP having the highest rating after control in texture (4.5), taste (4.7), flavour (4.8) and appearance (4.7) using a 6-point scale with 6 as extremely liked and 1 as extremely disliked. Breads with improved nutrients composition and acceptable sensory qualities can be produced from wheat flour and OFSP flour blends. Thus, wheat and OFSP composite flour is recommended for use in the production of acceptable breads of high nutritional quality.

INTRODUCTION
Bread is made from dough made of flour and water and is typically baked. It is one of the most popular foods throughout the world (Onoja *et al*., 2011). The consumption of bread in Nigeria is on a steady increase because it is a convenient and ready to eat food normally consumed at breakfast, lunch, and sometimes dinner. Despite the outstanding qualities of wheat flour for bread making, wheat flour is low in health-promoting bioactive compounds like vitamins (A, D,E, B_1, B_2 and B_{12}), beta-carotene, polyphenols and flavonoids as well as dietary fibre (Liu, *et al*., 2020).

According to the World Health organization (WHO), a large number of people in sub-Saharan Africa whom starchy foods dominate their food intake and are resource poor to purchase processed food that are fortified with micronutrients (WHO, 2011). Therefore, these individuals suffer from micronutrient malnutrition (hidden hunger) which mostly affects the infants, children, women of reproductive age and the aged; a population generally referred to as vulnerable groups. Many of the vulnerable groups suffer deficiencies of essential micronutrients such as vitamin A, zinc, iodine, and iron (Akombi, *et al*., 2019). Micronutrient malnutrition is a major risk factor for the increased incidence of under-nutrition leading to inhibited cognitive abilities, Vitamin A deficiency, weak immune system, anemia, night blindness in pregnant women and children, retarded growth, impeded reproductive potentials, increase the risk of diseases, and ultimately death (Kamanga and Mndala, 2019). Promoting the consumption of micronutrient-rich food can contribute to the reduction of micronutrient deficiencies with minimal resource investments (Mwanga, *et al*., 2017). Consequently, Low, *et al*. (2017), Shasha, (2011), Ukpabi, *et al*.

(2012), and Nwankwo and Bassey, (2013) opined that one of the most effective ways of liberating at-risk people is through development of selective breeding of sweet potato with high-carotene germplasm.
Orange-fleshed sweet potato (OFSP) is one of the sweet potato varieties being promoted in sub-Saharan Africa as a food-based measure to complement other efforts in reducing the occurrence of Vitamin A Deficiency (VAD) in this region (Kapinga, 2007; Low, *et al*., 2009; Tumwegamire, *et al*., 2004). It is a vital crop that contributes to the advancement of nutritional status and its consumption is one of the dietary strategies adopted to attack the deficiency of Vitamin A in sub-Sahara Africa (Okello, *et al*., 2018). Studies have indicated that consumption of boiled roots improved the vitamin A markers in adults and children (Hotz *et al*., 2012; Low *et al*., 2017). In spite of its nutritional value, OFSP is underutilized in Nigeria compared with other root and tuber crops consumed. OFSP has been found to be a good composite to wheat flour. This study therefore, aimed at assessing the nutrients values and sensory attributes of bread made from composite flours of wheat and OFSP.

MATERIALS AND METHODS

Materials

OFSP roots were obtained from a farm at Vandikyar, in Benue state, Nigeria. Other ingredients such as wheat flour, butter, salt, milk, yeast and sugar for baking were purchased from Lafia modern market in Nasarawa state.

Methods

Preparation of Orange-fleshed sweet potato into flour and formulation of composite flour blends

The OFSP roots were sorted to remove weevil infested ones, washed with clean water, peeled, sliced and soaked for 24 hours, then dried in an oven at 65°C for 8 hours until it becomes brittle. The brittle shredded OFSP was grounded through a corn meal grinder and passed through a mesh sieve. The flour was then packed in plastic container. The ratios of wheat flour and OFSP composite flour blends was 100:0, 75:25, 50:50, 25:75 and 0:100. Other ingredients used in bread production were added.

Preparation of Dough and Baking

The flour dough was prepared according to the method used by Akubundu, (2005). The composite flours dough were prepared and baked according to the method specified by the National Root Crop Research Institute, Umudike, (IITA, 2002; Eddy, 2007). Baking was carried out in food laboratory in College of Agriculture, Sciences and Technology Lafia.

Chemical Composition of flour

Moisture, fat, ash, crude fibre, protein contents of the flour blends were determined using the AOAC (2010) methods and total carbohydrate was calculated by difference while energy was calculated using the Atwater Conversion factors in Kcal. β-carotene was determined spectrophotometrically as described by AOAC (2010) method.

Sensory Evaluation

Bread samples were allowed to cool and organoleptically examined for the attributes by selected semi-trained panellist (N=15) consisting of staff and students of the Department of Nutrition and Dietetics and Home & Rural Economics, College of Agriculture, Sciences and Technology Lafia, Nasarawa state. The bread samples were 3-digit coded and presented to the panelists in white plastic plates. Each sample was rated on perceived intensities of standard sensory attributes (Taste, Colour, Texture, Appearance and General Acceptability) using a 6-point scale with 6 as extremely liked and 1 as extremely disliked. Drinking sachet water was served in glass to the panelists, and they were told to rinse their mouths after tasting each bread sample. Most panelists were between the ages of 18–35 years and were regular consumers of breads.

Statistical analysis

Experiments were conducted in triplicate. The means and standard deviations (SD) were calculated taking all the readings into consideration. Statistical analysis was performed using SPSS (Statistical Package for Social Sciences, version 21.0). One-way ANOVA (Analysis of variance at the level of significance ($p \leq 0.05$) was performed to ascertain the significance of the means.

RESULTS AND DISCUSSION

Proximate composition and β-carotene contents of composite flours

Total carbohydrate, moisture, crude proteins, crude fats and caloric values of wheat and OFSP composite flour were presented in Table 1. The proximate composition of the composites flours were not significantly different ($p \leq 0.05$). The crude protein content of 100% wheat flour was the highest (11.92%), while that of 100% OFSP flour was the lowest (4.90%). Carbohydrate contents of the flour blends were 75.54, 71.10, 74.13, 74.58 and 74.40% respectively, for 100% wheat flour; 75% wheat and 25% OFSP flour; 50% wheat and 50% OFSP flour; 25% wheat and 75% OFSP flour and 100% OFSP flour. The highest carbohydrate contain in 100% wheat flour is as a result of it lowest fiber contain because it's a refined flour. Crude protein content of the composite flours ranged from 11.91% in 100% wheat flour to 8.75% in sample substituted with 75% OFSP flour. The highest value was observed in 100% wheat flour and that is because wheat is a rich source of protein compared to OFSP. The protein content of wheat flour in this study is slightly higher than that of Calderon *et al*. (2022), which reported that protein content in their study had a protein level of 11.6. Crude fat ranged between 1.74% in 100% wheat flour to 1.18% in flour substituted with 75% OFSP flour. Addition of OFSP flour to wheat flour reduced the protein and fat contents of the flour blends, while ash, carbohydrate and β-carotene contents increased by the increase of OFSP flour to the blends. This could be attributed to the reduction in the amount of wheat flour in the composite flour blends. Wheat flour is a rich source of protein and fat compared to OFSP flour, which has the bulk of nutrient as carbohydrate and Crude fiber. The caloric values ranged from 328.18 to 365.46 kcal/100g (table 1). The higher calorie value observed in 100% wheat flour may be because of it higher fat, protein, and carbohydrate and lower fiber contents. The ash (2.44%) contents of 100% OFSP flour sample is slightly higher than those in sample substituted with 75% (1.60%), 50% (1.65%), and 25% (2.22%) wheat flour, respectively. Ash content increases with increasing amount of OFSP flour. The ash content was similar to the one reported by Nurminah, and Nainggolan, (2019). An increase in ash and β-carotene contents with an increase in the amount of OFSP flour in the blends indicates that bread made from OFSP contain minerals and vitamins that are high enough and good for people who want to get more valuable food products, not just eating, but getting more nutritional benefits. The β-carotene contents of the composite flour blends increased with increasing proportion of OFSP flour in the blends, values ranged from 0.211 mg/100g in 100% wheat flour to 7.89 mg/100g in 100% OFSP flour. The β-carotene level in 100% OFSP is lower than that (8.64 mg/100g) reported by Kolawole *et al*. (2021). Vitamin A is a fat-soluble vitamin that is naturally present in many foods as β-carotene. It is important for normal vision, immune system, and reproduction. Deficiency of this nutrient is one of the major challenges facing developing nations. Vitamin A deficiency can lead to night blindness and other acute diseases.

Table 1: Proximate and β-carotene Composition of Wheat-Orange-Fleshed Sweet Potato Composite Flour

Sample	Moisture (%)	Crude Protein (%)	Crude Fat (%)	Total Ash (%)	Crude Fiber (%)	Carbohydrate (%)	Caloric Value (Kcal/100g)	β-carotene (mg /100g)
W_{100}	9.64^a±0.01	11.91^a±0.07	1.74^a±0.02	0.93^a±0.02	0.24^a±0.01	75.54^a±0.05	365.46±0.08	0.211^a±0.03
$W_{75}OFSP_{25}$	10.86^a±0.02	11.90^a±0.20	1.62^a±0.02	1.60^a±0.02	2.90^a±0.006	71.10^a±0.22	346.58±1.85	3.94^a±0.03
$W_{50}OFSP_{50}$	9.10^a±0.46	10.20^a±0.08	1.52^a±0.02	1.65^a±0.03	3.40^a±0.07	74.13^a±0.53	351.00±1.68	5.27^a±0.03
$W_{25}OFSP_{75}$	8.72^a±0.02	8.75^a±0.02	1.18^a±0.02	2.22^a±0.02	4.55^a±0.02	74.58^a±0.03	343.94±1.78	6.58^a±0.36
$OFSP_{100}$	9.92^a±0.02	4.90^a±0.12	1.22^a±0.01	2.44^a±0.02	7.17^a±0.01	74.40^a±0.10	328.18±0.96	7.89^a±0.02

Values are means ± standard deviations of 3 replicates. Means with same the superscripts in the same column are not significantly (p>0.05) different. OFSP = Orange-Fleshed Sweet Potato; W = wheat.

Sensory properties of Breads

The sensory attributes scored were texture, taste, flavour, appearance and general acceptability and the result of the mean scores is presented in Table 2. The result obtained showed that 100% wheat bread (control) had the highest mean scores of 5.2, 4.8, 5.3, 5.3 and 5.2 in texture, taste, flavour, appearance and general acceptability respectively; followed by bread produced from wheat substituted with 75% OFSP wheat flour with the mean scores 4.5, 4.7, 4.8, 4.7, and 4.6, respectively in texture, taste, flavour, appearance and general acceptability, while bread produced from 100% OFSP flour had the lowest mean scores in texture, taste, flavour, appearance and general acceptability (3.9, 4.3, 4.6, 4.2 and 4.2, respectively). There was decrease in the mean scores as OFSP flours were added however the decrease was not significant (P>0.05). The study revealed that the more OFSP flour is added, the lower the sensory values. The higher rating for the control sample may be due to the fact that the panelists are familiar with wheat bread, while the low ratings for other breads produced from composite flours substituted at various ratios and 100% OFSP flour may be due to the panelists not being familiar with the breads. In general, all the bread samples compared well with the control sample, and were well accepted. Consequently, the study has shown that OFSP flour could be used with wheat as composite flours to produce acceptable bread.

Table 2: Mean Sensory Scores of breads produced from Wheat and OFSP Composite Flour

Samples	Texture	Taste	Flavour	Appearance	General acceptability
A	5.2^a	4.8^a	5.3^a	5.3^a	5.2^a
B	4.5^a	4.7^a	4.8^a	4.7^a	4.6^a
C	4.3^a	4.7^a	4.7^a	4.4^a	4.7^a
D	4.1^a	4.4^a	4.6^a	4.4^a	4.3^a
E	3.9^a	4.3^a	4.6^a	4.2^a	4.2^a

Values within a column with the same superscripts are not significantly>0.05 different. A=Bread produced from 100% Wheat flour, B=Bread produced from 75% Wheat and 25% OFSP flour, C=Bread produced from 50% Wheat and 50% OFSP flour, D=Bread produced from 25% Wheat and 75% OFSP flour, E=Bread produced from 100% OFSP flour.

CONCLUSIONS AND RECOMMENDATION

Orange-Fleshed Sweet Potato, β-carotene staple crop, can be used as a substitute and or alternatives to wheat flour for the preparation of a number of food products such as breads, cakes, biscuits and other bake products. It is generally used in foods to improve the sensory properties and enhance the nutritional values as well as reducing the over relying on high cost wheat for baking and confectionaries. The use of OFSP flour, however, is recommended to produce acceptable breads of good sensory and nutritional quality.

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PROFITABILITY ANALYSIS OF CASSAVA VALUE CHAIN AMONG AGRO-PROCESSING PRODUCTIVITY ENHANCEMENT AND LIVELIHOOD IMPROVEMENT SUPPORTS (APPEALS) BENEFICIARIES IN KOGI STATE, NIGERIA: PROSPECTS FOR YOUTH INVOLVEMENT

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ABSTRACT
The cassava value chain presents a critical avenue for economic growth, and analyzing its profitability offers insights into optimization opportunities, with particular emphasis on exploring the feasibility of youth involvement to ensure long-term sustainability and innovation. This study analysed the profitability of cassava value chain among Agro-processing Productivity Enhancement and Livelihood Improvement Supports (APPEALS) beneficiaries in Kogi State, Nigeria. Primary data obtained through questionnaire administration to 210 APPEALS beneficiaries were analysed using descriptive statistics and gross margin analysis. Findings from the study showed that 80% of the farmers were males and 20% were females; 75% and 78% of the female respondents were processors and marketers, respectively. Gross margin of ₦241, 937.70 and net margin of ₦237,986.85 were obtained, among cassava farming beneficiaries. The return on investment among the farmers was 4.50. The cassava processors recorded a positive gross margin with a mark-up of about 28% and 98% among the garri and fufu processors, respectively. The marketers recorded a gross margin of ₦109, 598.65, a net return of ₦ 105,708.10, and an RoI of 1.27. In conclusion, the profitability analysis showcased the viability of cassava value chain for beneficiaries through substantial gross and net margins, along with a strong return on investment (ROI). The study's findings underscore the economic viability of the cassava value chain, providing a compelling rationale for youth engagement.
Keywords: *APPEALS, beneficiaries, cassava, value chain, profitability, youth.*

INTRODUCTION
A value chain is the set of activities that producers engaged to produce agricultural commodities (De Marchi *et al.*, 2018). Along the chain, value is added which give such product a competitive advantage in terms of quality and attracting a higher price at the market (Gereffi, 2018). Value chain encompasses series of activities or processes that aims at creating and adding value to an article (product) within it, analyzing the opportunity cost of the new sequence along the product worth (Lee *et al*., 2018). According to Mbanjo *et al* (2020), more than 291 million tons of cassava were produced worldwide in 2017, of which Africa accounted for over 60%. In 2017, Nigeria produced 59 million tons making it the world's largest producer (approximately 20% of global production) with a 37% increase in the last decade. Nigeria exports about 3.2 million tons annually and earned a record $136 million in 2013. The crop can serve as; food, flour, animal feed, alcohol, starches for sizing paper and textiles, sweeteners, prepared foods and bio-degradable products. These products are derived from several forms, ranging from fresh leaves and roots to modified cassava starch (Agricultural Research Council, ARC 2019).
Agro-Processing Productivity Enhancement and Livelihood Improvement Supports (APPEALS) is a Federal Government of Nigeria FGN-World Bank Assisted project. The aim of this intervention is to enhance the productivity of small and medium scale farmers and improve value addition along priority value chains (Rice, Wheat, Cassava, Cocoa, Cashew, Aquaculture, Poultry, Maize, Dairy, Ginger, and Tomato) in the participating States of Kogi, Cross River, Kaduna, Kano, and Lagos States. According to the Federal Ministry of Agriculture and Rural Development (FMARD), the project has five (5) components, including production and productivity enhancement; primary processing, value addition, post-harvest management and women and youth empowerment;

infrastructure support to agribusiness clusters; technical assistance, knowledge management and communication; project management and coordination.

The Kogi State APPEALS is aimed at boosting agricultural productivity, value addition, and livelihoods in Kogi State, Nigeria. This project focuses on empowering smallholder farmers and agribusinesses by providing targeted support, including improved agricultural techniques, access to modern technologies, and enhanced market linkages. APPEALS in Kogi State emphasizes key agricultural value chains such as rice, cassava, and cashew, aiming to enhance their competitiveness and sustainability. The cassava value chain plays a significant role in driving agricultural transformation and rural development. This initiative focuses on enhancing various aspects of the cassava value chain to improve productivity, increase income for smallholder farmers, and promote agribusiness growth. APPEALS project employs a multi-faceted approach that includes improved farming techniques, assess to quality inputs, value addition and processing, market linkages, entrepreneurship and agribusiness development, and capacity building.

The present study with focus on profitability analysis along the cassava value chain with prospects for youth involvement is crucial to address several pertinent challenges. Firstly, understanding the economic viability of each link in the cassava value chain is essential to identify potential bottlenecks and areas for optimization. This analysis can provide valuable insights into where value addition and efficiency improvements are most needed. From this foundation, understanding the potential for youth engagement becomes pivotal, as it will be driven by the economic viability uncovered in the analysis. Linking profitability outcomes with youth prospects ensures a strategic alignment between economic viability and youth inclusion. By substantiating youth involvement opportunities with profitability data, the study can guide targeted policies and interventions that not only optimize economic gains but also channel the energies of the youth towards sustainable agricultural entrepreneurship, thereby fostering both economic growth and meaningful youth engagement within the cassava sector.

METHODOLOGY

The area of study is Kogi State, Nigeria. The State is located between latitudes 7°30’N and 7.500^{0}N longitudes 6^{0}42’E and 6.700^{0}E with an area of 29,833km2 and a population of 4,473,490 in 2016 estimated from 2006 census (NPC 2016). The study adopted quantitative research approach. As provided by the Agro-processing Productivity Enhancement and Livelihood Improvement Support, (APPEALS), Kogi State has ten (10) cassava clusters with a total of four hundred and fifty-nine (459) beneficiaries. The respondents were drawn using a multistage random sampling technique to obtain a total sample size of 210 respondents (70 farmers, 70 processors, and 70 marketers). The primary data obtained through questionnaire administration were analysed using descriptive statistics and the Gross Margin Analysis.

The Gross Margin analysis used in this study is as follows:

$GM = TR – TVC$ Profit = $TR – TC$…… eqn1

Where:

TR = Total Revenue, TVC = Total Variable Cost, TC = Total Cost, GM = Gross margin,

$NI = GM – TFC$ ………………eqn2

Where:

NI = Farm Net income (N/ha), TFC = Total fixed cost (N/ha).

The fixed cost includes depreciation of fixed assets computed using the straight-line method of depreciation (3 years).

RESULTS AND DISCUSSION

Socioeconomic Characteristics of Actors along the Cassava Value Chain

Table 1 presents selected socioeconomic characteristics of APPEALS beneficiaries along the cassava value chain. Males are more actively involved in cassava farming which could be associated with the nature of activities expected to be performed in production/farming activities. The mean age (32, 30, 33 years) across these value chain actors could be regarded as active and productive age. In Nigeria’s age categorization, the actors are basically youth in their productive age. This age category is necessary for high productivity in the cassava value chain. The marital status distribution of the respondents as shown in Table 1 indicates that more married actors are found across the cassava value chain. The result is expected because married people are societally assumed to be more responsibly and ready to provide daily meals for their households. Hence, their involvement in income generating activities such as cassava production, processing, and marketing. The finding on education is expected to positively influence beneficiaries’ adoption of innovation for improved productivity. The mean production, processing and marketing experience in this study shows that farmers, processors, and marketers had considerable years of experience which is an advantage towards production and adoption of technologies in the cassava value chain. Membership of an association is expected to enhance information dissemination and efficient production, processing, and marketing of cassava. The findings of this study on socioeconomic characteristics agree with previous empirical studies; see for example: Ekwe *et al*. (2017), Sirela (2018) and Osuji *et al*. (2017).

Table 1: Socioeconomic Characteristics of Actors in the Cassava Value Chain

	Farmers, n = 70			Processors, n = 70			Marketers, n = 70		
Socioeconomic Characteristics	Freq.	%	Mean	Freq.	%	Mean	Freq	%	Mean
A. Sex									
Female	56	80.0		17	24.29		15	21.43	
Male	14	20.0		53	75.71		55	78.57	
B. Age (years)									
15 – 35	50	71.43	32yrs.	55	78.57	30yrs.	46	65.71	33yrs
36 – 55	13	18.57		10	14.29		13	18.57	
56 – 75	7	10.0		5	7.14		8	11.43	
76 Above	0	0		0	0		3	4.29	
C. Marital Status									
Single	25	35.71		126	37.14		24	34.29	
Married	30	42.86		35	50.0		30	42.86	
Widow	2	2.86		3	4.29.0		6	8.57	
Widower	2	2.86		1	1.43		4	5.71	
Divorced	11	15.71		5	7.14		6	8.57	
D. Household Size (number)									
1 – 15	43	61.43	13 members	39	55.71	14members	36	51.43	14 members
16 – 25	21	30.0		23	32.86		28	40.0	
26 – 35	6	8.57		8	11.43		6	8.57	
36 Above	0	0		0	0				
E. Educational Background									
No formal education	18	25.71		20	28.57		33	47.14	
Primary education	12	17.14		18	25.71		10	14.29	
Secondary education	37	52.86		30	42.86		20	28.57	
Tertiary education	3	4.29		2	2.86		7	10.0	
F. Business Experience (yrs.)									
1 – 10	28	40.0	12 yrs.	46	65.71	9yrs.	27	38.57	12yrs.
11 – 25	33	47.14		17	24.29		30	42.82	
26 Above	9	12.86		7	10.0		13	18.57	
G. Cooperative Membership									
Member	49	70.0		60	85,71		65	92.86	
Non member	21	30.0		10	14.29		5	7.14	

Source: Field Survey Data, 2023.

Profitability among Enterprise within the Cassava Value Chain

The gross margin and profitability analysis of cassava farming enterprise is presented in Table 2. The result showed a gross margin of ₦241, 937.70 while net margin was ₦237,986.85, providing evidence of profitability of cassava farming among the beneficiaries. The return on investment was 4.50 indicating that for every ₦1 invested, ₦4.50k is earned. This result agrees with the findings of Njukwe *et al.* (2014); Olukunle (2013); Emerole *et al* (2014); and Odemero (2015) who found that for every ₦1 invested in cassava production, more than ₦1 is returned as an added value to initial money invested.

The Gross margin of garri per basket of tuber and fufu/flour are presented in Table 3. The analysis was carried out based on weekly production activities of the processors (using one basket of tubers). This approach was adopted because processing and sales among small scale processors were done on weekly basis. Table 3 shows a generally low gross margin and profit for *garri* enterprise and the *fufu* or flour processing industry. *Fufu* had both a higher profit and mark-up, and a better monetary prospect as compared to the *garri*. Narsey (2013) has stated that items with low turnover rates (field observation shows that garri had a higher demand rate and turnover) have higher carrying costs and require higher mark ups for a reasonable profit to be made. Items with higher turnover have lower mark ups. This may have accounted for the higher mark up in *fufu* sales as observed among APPEALS beneficiaries.

The average costs and return analysis in the cassava marketing enterprise is presented in Table 4. The gross margin was ₦109, 598.65 while the net return was about ₦ 105,708.10. The implication is that the cassava marketing is a profitable venture among the APPEALS beneficiaries. This result was further corroborated by the return on investment (RoI).

Table 2: Average costs and return among cassava farmers

Variables	Unit	Price	Quantity	Value (₦)
Total Revenue	Tonnes	450,000.50	0.68	306,000.34
Variable Costs				
Land preparation	Man-day	1,800	4.0	12,600.00
Herbicide application	Man-day	1,800	1.0	1,800.00
Planting	Man-day	1,800	3.5	6,300.00
Weeding	Man-day	1,800	3.0	5,400.00
Fertilizer application	Man-day	1,800	2.0	3,600.00
Pesticide application	Man-day	1,800	1.0	1,800.00
Harvesting	Man-day	1,800	3.0	5,400.00
Stem cost	Bundles	450.55	4.8	2,162.64
Cost of fertilizer	Bag	5,500.00	1.3	7,150.00
Cost of pesticide	Litres	2,850.00	3	8,550.00
Cost of herbicide	Litres	3,000.50	1.5	4,500.00
Transportation and other charges	Naira	-	Lump sum	4800.00
Total Variable Costs				64,062.64
Total Fixed Costs (Depreciated)				3,950.85
Total Costs (TVC+TFC)				68,013.49
Gross Margin (GM = TR – TVC)				241,937.70
Net Margin (NM = TR – TC)				237,986.85
Return on Investment				4.50

Source: Field Survey, 2023.

Table 3: Profitability in the cassava processing enterprise

Average variable cost/enterprise	Value (₦)	Returns per enterprise	Value (₦)
Garri per basket of tuber			
Raw tubers	2,850.50	Sales from *Garri*	6,950.55
Labour	1,500.00		
Grating	250.00		
Fuel (wood)	650.00		
Packaging/bags	200.00		
Total	5,450.50		
Gross Margin	1,500.05		
Mark-Up	27.52%		
Fufu/flour			
Raw tubers	3000.55	Sales from *fufu*/flour	10,580.55
Labour	1,800.50		
Others	550.00		
Total	5,351.05		
Gross Margin	5,229.50		
Mark-Up	97.72%		

Source: Field Survey, 2023

Table 4: Profitability of cassava marketing (Aggregators) per Tonne

Items	Average Value (₦)
Total Revenue	495,500.45
Variable Costs:	
Purchasing cost	320,000.50
Transportation	53,550.85
Market charges	10,350.45
Total Variable Cost, TVC	385,901.80
Fixed Cost	
Rent	3,890.55
Total Fixed Cost	3,890.55
Total Cost	389,792.35
Gross Margin	109,598.65
Net Margin	105,708.10
RoI	1.27

Source: Field Survey, 2023.

CONCLUSION AND RECOMMENDATIONS

The profitability analysis demonstrated substantial gross and net margins, underscoring the viability of cassava farming for beneficiaries, as evidenced by a robust return on investment (ROI) of 4.50. Moreover, cassava processing indicated favorable outcomes, with significant positive gross margins and mark-ups observed, while cassava marketing emerged as a profitable endeavour among APPEALS beneficiaries, yielding substantial gross margins, net returns, and an ROI of 1.27. The demonstrated profitability, coupled with the potential for innovation and sustainable entrepreneurship, presents a compelling case for involving youth in the cassava sector. This engagement not only ensures the sector's long-term vibrancy but also contributes to addressing youth unemployment and fostering inclusive agricultural development. Based on findings from this study, the following recommendations are made:

1. Building upon the observed gender distribution and roles, APPEALS, Kogi State government and other relevant stakeholders should establish tailored training programs that equip both male and female youth with the necessary skills for different stages of the cassava value chain. By providing comprehensive training in farming, processing, and marketing, youth can contribute effectively to various segments, fostering inclusivity and ensuring a skilled workforce.
2. Capitalizing on the profitability demonstrated by cassava farming, processing, and marketing. The government should develop youth-focused entrepreneurship support programmes that offer accessible funding, mentorship, and guidance for starting and sustaining ventures along the value chain. Encourage youth to leverage the positive gross margins and mark-ups identified, nurturing a new generation of agripreneurs.
3. Given the substantial role of technology in the cassava value chain's profitability, APPEALS and State government should establish youth-oriented technology hubs. These hubs should provide resources for youth to learn, adopt, and innovate with modern technologies in farming, processing, and marketing. Such an approach taps into the tech-savvy nature of youth, aligning their interests with the sector's growth and sustainability.

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DETERMINANTS OF VALUE ADDITION AMONG RICE PROCESSORS IN BENUE STATE, NIGERIA

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ABSTRACT
The study analyzed determinants of value addition among rice processors in Benue state, Nigeria. A multistage sampling technique was used to sample 252 rice processors in six local government areas of Benue State namely: Agatu, Gwer-East, Makurdi, Otukpo, Kwande and Gboko based in the intensity of rice processing activities. A structured questionnaire was used for data collection. Descriptive statistics was used to analyze objective one and double log regression analysis was used to achieve objective two. The result shows that the major challenges confronting rice processors in the study area low quality of paddy rice, high transportation cost, and limited access to post-harvest and market facilities. Other challenges that also ranked are high capital requirement, lack of improved storage facilities, lack of improved rice threshing machines, limited access to working capital, and insufficient modern mechanical drying facilities. The result of the regression analysis shows that majority of the independent variables have positive elasticities as expected which implies that these variables have positive influence on value addition among rice processors in the study area. The coefficients of level of education, income, access credit, access market, processing experience and price of rice product are positive and statistically significant at 5 % level of probability indicating that 5 % increase level of education, income, access credit, access market, processing experience and price of rice product will increase rice value addition by 1.27 %, 4.37 %, 6.36 %, 4.04 %, 4.00 % and 9.35 % respectively. The coefficients for household size and processing cost are negative and statistically significant at 5 % level of probability. This implies that a 5 % increase household size and processing cost would lead to 1.96 % and 4.23 % decrease in rice value addition when other variables are constant. Therefore, policy measures aimed at increasing the level of education, income, access credit, access market and processing experience of rice processors are recommended to burst rice value addition in the study area.

Keywords: *Determinants, Value addition, Rice, Processors*

INTRODUCTION
Rice is the most economically important food crop in many developing countries and has also become a major crop in many developed countries where its consumption has increased considerably (Ajala & Gana, 2015). Over the past few decades, rice has become of the leading food staples in Nigeria, surpassing cassava in food expenditure. Rice consumption is estimated to be rising at 5.1% annually and is expected to reach 36 million metric tons (MT) by 2050 (Federal Ministry of Agriculture and Rural Development (FMARD), 2011. The demand for rice in Nigeria is estimated to be 5 million metric tons (MT) yearly (Johnson & Masias, 2017). It has been reported that rice consumption has increased fast than production, resulting in a growing dependency on import (International Food Policy Research Institute, IFPRI, 2016). The demand for rice has grown significantly over the last 40 years is attributable changing consumer dietary patterns and population growth. Nigeria spends about N356 billion annually for about 2 million MT of milled rice (FMARD, 2011). It has become necessary to meet the demand of the world's current population growth rate through value addition. Value addition in the processing and marketing of rice including all the activities, processes or strategies and distribution of rice which in one way or the other contribute to benefit/utility maximization (Ugwu, Mgbakor, & Chitor 2014).
The benefits of value addition are many. Some scholars for example: Jessie, Kumar, Chaitanya & Reddy (2022); Suneetha, Kumar, Rao & Prasad (2020) stated that creation of employment opportunities, increasing business's profit and profit margin, mitigation of imbalance of trade, improvement in the host country's gross domestic product (GDP) are benefits derivable from value addition in paddy rice. In spite of the perceived benefits of rice

value addition to the Nigerian economy and Benue State in particular being the "Food Basket of the Nation", there are no sufficient empirical evidence to show that actors in the rice value chain have been studied. This situation calls for concern. It has become necessary to study the determinants of value addition of a major staple grown, eaten and traded in different parts of Benue State. It is therefore imperative to undertake a study of this nature because of the significance of rice in the socioeconomic lives of Benue people.

METHODOLOGY

This study was conducted in Benue State of Nigeria. The state was chosen based on the intensity of rice production in the region. A multistage sampling procedure was employed in selecting the respondents for the study. The first stage involved the purposive selection of six local government areas (LGAs) namely: Agatu, Gwer-East, Makurdi, Otukpo, Kwande and Gboko LGAs based on the intensity of rice value addition activities as captured by Benue Value Chain Development Programme (VCDP) office (BN/FGN/IFAD-VCDP, 2021). In the second stage, to ensure even distribution of the sample for the study, a judgmental sampling method was used to select twelve (12) milling communities in the selected six LGAs namely: Agatu and Obagaji in Agatu LGA; Aliade and Taraku in Gwer East LGA; Wadata and Wururkum in Makurdi LGA; Otukpo and Mile 4 in Otukpo LGA; Adikpo and Jato Aka in Kwande LGA; and Gboko-west and Tse-Kucha in Gboko LGA based on the predominance of the rice value chain actors. In the third stage, two hundred and fifty two (252) rice processors were selected from the list of rice processors registered with Benue Value Chain Development Programme (VCDP) BN/FGN/IFAD-VCDP, 2021) for the analysis of value addition among rice processors.

Data were collected with aid of a structured questionnaire. Descriptive statistics was used to realize objective one and multiple regression model was used to achieve objective two. Following Nyor & Mbanasor (2018), regression model was adopted for the analysis and specified as follows:

$$\ln Y_i = b_0 + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + b_7 \ln X_7 + b_8 \ln X_8 + b_9 \ln X_9 + b_{10} \ln X_{10} + b_{11} \ln X_{11} + + e_i \quad (1)$$

Where: Y_i = value addition proxies by quantity of rice processed (Kg), X_1 = age (Years), X_2 =Sex (Male=1, otherwise =0) , X_3 = level of education(years), X_4 = Household size (number), X_5 = Income (₦), X_6 = access to credit (1 = yes, 0 = otherwise), X_7 = access to market(1 = yes, 0 = otherwise), X_8 = processing experience (years), X_9 = Processing cost (₦), X_{10} = price of rice product (₦), ln = natural logarithm, b_0 = intercept on dependent variable, $b_1 – b_{10}$ = parameters to be estimated, and e_i = error terms.

Equation (1) predicted that value addition will be positively affected by level of education, income, access to credit, access to market, processing experience and price of rice product and will be negatively affected by age, household size and processing cost. The model linearized so as to standardize the variables.

RESULTS AND DISCUSSION

The result in Table 1 shows the challenges to rice processing among processors in the study area. The result indicated that the most serious challenge to rice processing in the study area is low quality of paddy rice followed by high transportation cost, and limited access to post-harvest and market facilities. Other challenges that also ranked are high capital requirement, lack of improved storage facilities, lack of improved rice threshing machines, limited access to working capital, and insufficient modern mechanical drying facilities.

Table 1: Challenges faced by ice processors in the study area (n=252)

Challenges	Mean score	Rank
Low quality of rice	3.90	1st
High transportation cost	3.80	2nd
Lack access to post-harvest and market facilities	3.80	2nd
High capital requirement	3.79	4th
Lack of improved storage facilities	3.58	5th
Lack of improved rice threshing machines	3.51	6th
Limited access to working capital	3.50	7th
Insufficient modern mechanical drying facilities	3.49	8th
Insufficient modern milling facilities	3.40	9th
High cost of electricity and diesel	3.39	10th
Insufficient modern weighing facilities	3.30	11th
Lack of appropriate market facilities	3.29	12th
Insufficient modern storage facilities	3.10	13th
Lack of improved rice huller or polisher	2.99	14th
Limited credit	2.89	15th

Source: Computed from field survey data (2023)

Challenges with mean score ≥3.0 (median of the 5-point likert scale) are considered serious.
The result suggests that for a rice processor to achieve good quality output in processing rice the quality of paddy rice should be a matter of priority. In conformity, Okunola, Adekanye, Adewumi, & Ashamu (2019) who identified contamination of rice with stones and other impurities as one of the major constraints to rice processing operations in Ekiti State, Nigeria. The result of the ordinary least squares (OLS) estimates of determinants of value addition among rice processors is presented in Table 2. The double log regression model was accepted as lead equation based on its high value of R^2 adjusted, least standard error and more compliance with the a priori expectations. Majority of the variables have positive elasticities as expected which implies that these variables have positive influence on value addition among rice processors in the study area.

Table 2: Estimates of determinants of value addition among rice processors (n=252)

Variable	Linear	Exponential	Semi log	Double log
Constant	-49.553(-2.105) **	-87.201(-5.163) **	-24.613(-5.488) **	4.782(2.008) ***
Age	0.206(4.002)	1.003(2.001)	0.106(1.413) *	0.320(2.391) *
Sex	0.243(2.722)	0.452(0.341)	0.325(0.632) *	0.210(0.301) *
Level of education	0.127(-2.491)	0.256(-0.450) *	0.731(-0.916) **	1.273(-1.329)**
Household size	-1.843(-2.102) *	-0.038(-1.242)**	-1.451(-1.523) *	-1.967(-0.657) ***
Income	1.272(0.948)	0.386(0.540) **	1.549(0.482) *	4.374(1.476) ***
Access to Credit	1.753(1.109) **	1.356(0.361) **	0.528(0.731) **	6.361(3.215) ***
Access to Market	0.315(1.164)*	1.410(1.201) **	1.092(1.327) **	4.042(2.428)***
Processing Experience	0.219(1,843) **	0.714(0.263)*	1.753(1.525) **	4.002(4.020)***
Processing cost	1.371(1.629) **	-1.218(1.329) **	-1.528(1.427) **	-4.231(2.528)**
Price of rice product	0.106(0.732) **	1.008(1.261) ***	2.627(2.305) ***	9.351(3.327)***
Model Fitness Parameter				
R^2	0.426	0.481	0.403	0.624
Adjusted R^2	0.38.2	0.431	0.364	0.562
Std ErrorF-Stat.	44.325	20.476	23.541	3.634
F-Stat.	4.225	4,102	3.982	4.026
Prob.	0.000***	0.000***	0.000***	0.000***

Source: Computed from field survey data (2023)
***Significance at p≤0.01; **Significance at p≤0.05; *Significance at p≤0.10. Figures in parentheses are t-test statistics.

Dependent variable: Value addition proxies as quantity of rice processed in Kg.
The coefficients of level of education, income, access credit, access market, processing experience and price of rice product are positive and statistically significant at 5 % level of probability indicating that 5 % increase level of education, income, access credit, access market, processing experience and price of rice product will increase rice value addition by 1.27 %, 4.37 %, 6.36 %, 4.04 %, 4.00 % and 9.35 % respectively. The coefficients for household size and processing cost are negative and statistically significant at 5 % level of probability. This implies that a 5 % increase household size and processing cost would lead to 1.96 % and 4.23 % decrease in rice value addition when other variables are constant. The inverse relationship between rice value addition and cost of processing rice goes to explain the impact of escalating cost of inputs on investment.

CONCLUSION

The study analysed the determinants of value addition among rice processors in Benue state, Nigeria. The result shows that the major challenges confronting value addition among rice processors in the study area are low quality of paddy rice, high transportation cost, and limited access to post-harvest and market facilities. Other challenges that also ranked are high transportation cost, high capital requirement, lack of improved storage facilities, lack of improved rice threshing machines, limited access to working capital, and insufficient modern mechanical drying facilities. The result also shows that majority of the independent variables have positive elasticities as expected which implies that these variables have positive influence on value addition among rice processors in the study area. The coefficients of level of education, income, access credit, access market, processing experience and price of rice product are positive and statistically significant at 5 % significant level. The policy implication is that efforts aimed at enhancing level of education, income, access credit, access market, processing experience among rice processors should be encouraged. Therefore, in order to achieve sustainable value addition in rice processing and strengthening the rice value chain for food security, the escalating cost of production is worrisome and efforts should be made to address these challenges.

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RESPONSE SURFACE METHODOLOGY OPTIMIZATION OF CONVECTIVELY DRIED GINGER RHIZOME (*ZINGIBER OFFICINALE)*

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ABSTRACT
Drying is an energy intensive process that requires optimization for economic production. This study investigated, modeled and optimized the effect of convective drying factors (temperature (50, 55 and 60^{O}C), steam blanching time (20, 40 and 60 s), and air velocity (0, 1 and 2 m/s)) on the specific energy consumption of Ginger using response surface methodology (RSM). Results showed that all the drying factors considered increased the specific energy consumption during Ginger drying. The determined drying representative model has R-Squared and Adj R-Squared value of 0.9432 and 0.909 respectively. The determined optimum drying condition was drying temperature of 58.71^{O}C, steam blanching time of 20 s, and drier air velocity of 0.82 m/s to give a specific energy consumption of 119.04 kW.h. The results are useful for economic production of dried Ginger.

Keyword: *Ginger, specific energy consumption, response surface methodology, blanching time, drying*

INTRODUCTION
Ginger is an herb in plant habitat. It is consumed in both fresh and dried form because of its stimulating, aromatic, and carminative properties (Hoque *et al*., 2013). The phyto-medicinal importance of ginger is responsible for its large accompanied literature studies. The importance of drying to ensuring shelf stability, preservation, ease of transportation and storage of foods for future use cannot be overemphasized. Drying technology is popular and effective to prepare products for storage purposes (Majdi *et al.*, 2019). Over the years, drying has evolved from traditional open sun drying method to equipment enhanced sophisticated methods such as convective, microwave, freeze-drying, infrared drying and others. Amongst modern drying technologies, convective drying is easily implementable, especially in developing countries. However, a major backdrop of convective drying is the high-energy consumption, which has a detrimental effect on its economic consideration for adoption (Adeyi *et al*., 2022). Therefore, to make convective drying process more economically viable, the optimization of its specific energy consumption is important.

MATERIALS AND METHODS
Materials
Freshly harvested matured Ginger was obtained from a farmland in Ogbomoso Township, Oyo state, Nigeria. Stan gas convective dryer equipped with a temperature regulator, 3000 W heating element and timer was utilized for the drying experiment. A digital weighing balance (0.001 g accuracy) was employed for measurement purposes.

Experimental design
Experiments were designed to understand, model and optimize the individual and interactive effect of drying temperature ((X_1) = 50, 55 and 60^{O}C), blanching time ((X_2)= 20, 40 and 60 s), and air velocity ((X_3)= 0, 1 and 2 m/s) on the specific energy consumption (Y) of convectively dried Ginger. The drying factors and variations were selected based on literature search with special consideration for dried product quality preservation (Mercer, 2012). Design expert software version 8.0.0 (Stat-Ease, Inc., Minneapolis, USA) was utilized to design the experiment using miscellaneous Response Surface Methodology (RSM) and there were twenty-eight experimental runs altogether.

RSM modeling and optimization
Statistical analysis comprising of regression, graphical representation, and analysis of variance (ANOVA) were performed in the design expert software. The developed models were appraised by Mean squares, degree of freedom (DoF), sum of squares, F-value and, P-value are parameters. F-value determines the variance of data about the mean and better model precision is registered when F-values higher than one. P-values determine the model suitability statistically, P-value less than 0.05 is statistically acceptable. Thereafter, the optimum

combination of factors' parameters that best minimizes the process responses was determined. In addition, the RSM's established optimum process condition was experimentally validated. For statistical significance, triplicate validation experiments were conducted and their average is reported. The percentage error between the RSM's established theoretical optimum and its experimental validation was determined using Eqn. (1):

$$\alpha = \frac{Va - Ve}{Ve} \text{ X } 100\% \qquad (1)$$

Where α is the percentage error, *Va* is the experimental value and *Ve* is the theoretical value.

Drying procedure

Gingers were washed with portable water to remove sand and dirt followed by air-drying (28 – 30^{O}C) for 30 mins. The initial moisture content of ginger was determined using oven drying method at 90 ^{O}C for 24 h (AOAC, 1980). Equal sample weight of 10 g was utilized for each drying experimental run and was made to dry at the specified drying temperature, blanching time, and air velocity. The drying was done until equilibrium moisture content of the sample was reached. A digital weighing balance was utilized to measure the pre-drying and post-drying weight of the samples. Thereafter, the specific energy consumption were calculated using the experimental data through Eqn. (2) and (3) (Tunde-Akintunde, 2014), respectively.

$$E_t = Av\rho_a c_a \Delta T D_t \qquad (2)$$

$$E_s = \frac{E_t}{W_0} \qquad (3)$$

Where E_t, E_s, A, v, ρ_a, c_a, ΔT, D_t and W_0 is the total energy required for drying at each experimental run, specific energy consumption, the tray area, air velocity, the air density, specific heat capacity of the drying air, temperature difference, time of drying and initial weight, respectively

Results and Discussions

Effect of drying factors on specific energy consumption

The initial moisture content of ginger used in this study was 86 % (w.b). The effect of the selected drying factors on the specific energy consumption of ginger is represented in Fig. 1.

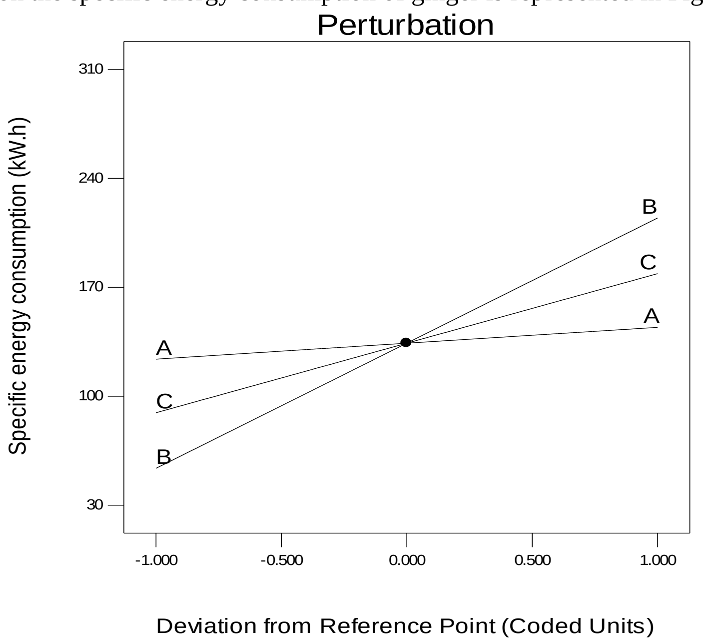

Fig. 1 Effect of the drying factors (A = Drying Temperature, B = Blanching Time and C = Air Velocity) on specific energy consumption

The figure showed that all drying factors led to increment in the specific energy consumption. The blanching time had the highest contribution to the specific energy consumption while temperature had the least contribution. The highest contribution of blanching is due to induced surface moisture on the sample after the blanching process. The least contribution of temperature is due to low electrical energy utilization as a result of low ranged drying temperature applied.

The model that represented the drying characteristics is represented in Eqn. 4

$$Y = +782.24 + 3.48 * A + 603.30 * B + 303.06 * C + 123.45 * A * B - 125.62 * A * C + 359.54 * B * C \quad (4)$$

Where Y= Specific energy consumption (kW.h)
The analysis of the model is represented in Table 1.

Table 1 Analysis of variance for specific energy consumption

Source	Sum of Squares	DoF	Mean Square	F Value	p-value Prob > F
Model	4.288E+006	6	7.146E+005	27.67	< 0.0001significant
A	97.00	1	97.00	3.755E-003	0.9523
B	2.912E+006	1	2.912E+006	112.72	< 0.0001
C	7.348E+005	1	7.348E+005	28.44	0.0003
AB	60963.61	1	60963.61	2.36	0.1555
AC	63122.27	1	63122.27	2.44	0.1491
BC	5.171E+005	1	5.171E+005	20.02	0.0012
Residual	2.583E+005	10	25831.53		
Lack of Fit	1.007E+005	6	16782.92	0.43	0.8323 not significant
Pure Error	1.576 E+005	4	3940	4.44	

R-Squared: 0.9432; Adj R-Squared: 0.9091; Pred R-Squared: 0.8483; Adeq Precision: 19.287

The Model F-value of 27.67 implies the model is significant. There is only a 0.01% chance that a Model F-Value this large could occur due to noise. Values of Prob > F less than 0.0500 indicate model terms are significant. In this case B, C, BC are significant model terms. Values greater than 0.1000 indicate the model terms are not significant. If there are many insignificant model terms (not counting those required to support hierarchy), model reduction may improve your model. The lack of fit F-value of 0.43 implies the lack of fit is not significant relative to the pure error. There is an 83.23% chance that a lack of fit F-value this large could occur due to noise. Non-significant lack of fit is good.

Optimization of drying process

The result of the optimization of the drying process is depicted in Fig. 2

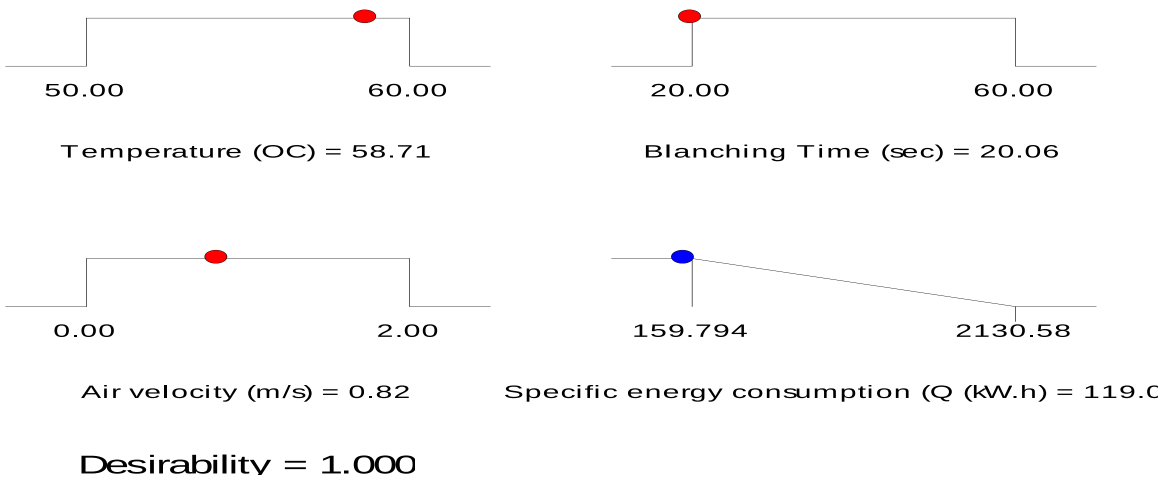

Fig. 2 Optimum drying process condition

The Figure 2 showed that the theoretical optimum drying condition of ginger for optimum specific energy consumption can be achieved at a drying temperature of 58.71^{O}C, blanching time of 20 min, and air velocity of 0.82 m/s. At this optimum drying condition, the dried product will consume specific energy of 119.04 kW.h. The desirability of this optimum drying condition is 1 which is the maximum that can be achieved. In a related study, Majdi *et al*., (2019) reported a desirability value of 0.781 for the optimum drying condition of apple.
The optimization result was validated so that its implementation in a large scale could be trusted. The validation error between the response values of the established theoretical processing condition and the response value of the experimental validation of the theoretical optimum processing condition (using the same input conditions of the theoretical processing condition values) was 0.284. This error is relatively low, and therefore, the RSM's established optimum drying condition can be reliably utilized.

CONCLUSION

The requirement for economic production of dried product is on the rise. Consequently, this study optimized the specific energy requirement during convective drying of ginger in response to selected drying conditions using Response Surface Methodology (RSM). The results implied that the optimal specific energy consumption of the convectively dried ginger was 119. 04 kW.h and could be achieved at drying temperature of 58.71^{O}C, blanching time of 20 mins, and drier air velocity of 0.82 m/s. This result is useful for economic production of dried ginger, which is one of the precursors for its commercialization.

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TRAINING NEEDS OF FARMERS ON ORANGE FLESHED SWEET POTATO VALUE ADDITION IN ABIA STATE, NIGERIA

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ABSTRACT

The study assessed the training needs of farmers on orange fleshed sweet potato value addition in Abia state, Nigeria. Data were collected from a sample of 120 farmers with the use of structured questionnaire. Frequencies, percentages and means were used for data analysis. The result show that majority (50.8%) were female, Majority (78.3%) of the respondent were married (43.33%) of the respondents fell within the age range of 60-69 years, (42.50%) of the respondents had secondary education. (46.67%) have household size of 4-6. The result also shown that Flour (94.2%), (Orange fleshed sweet potato drinks/juice (91.7%), Packaging (91.7%), Chips (89.2%), Skills for operating processing machines (89.2%), Flakes (86.7%), Meat Pie (85.8%), Selection of varieties for product processing (84.2%), are areas of training needs of the farmers. It was recommended that more awareness creation, training programmes and provision of suitable and necessary incentive should be disseminated by government, non-governmental organizations as well as research institution through extension agents should design programmes to train more sweetpotato farmers how to process sweet potato orange fleshed sweet potato roots into flour and juice for better returns.

Keywords: *Sweet potato, Training needs, Value addition, Farmers*

INTRODUCTION

Sweet potato (Ipomoea batatas) has different names in different languages such as Nduko in Igbo, Dankali in Hausa, Dun odunkun in Yoruba, batata or chaco in Spanish, Patatedouce in French, Patata americanain Italian, Batate in German, among others. It is a herbaceous warm weather creeping plant belonging to the family Convolvulaceae and genusipomomia. Sweet potato is one of the world's most important staple carbohydrate foods. Sweet potato is the fifth most important food crop on a fresh weight basis in developing countries after rice, maize, cassava and wheat. Sweet potato is high in nutritive value, outranking most carbohydrate foods in vitamins, minerals, protein and energy content. Depending on the cultivar, it is high in carotenoids, particularly, the hydrogen carotenoid, and the B-carotenoid which is a potent pro-vitamin A which is very important in nutrition and health of humans (CIP, 2012).

However, the processing of sweet potato into chips, snacks are not common in Nigeria due to inadequate information on processing technologies and various characteristics of products utilization. The poor quality of traditionally dried crop that has retained moisture for too long results from poor processing. This traditionally dried crops result in moldiness, micro toxin contamination and early insect infestation which leads to low or outright rejection of products. Quality sweet potato processing has potential for production of primary products, preservation, conservation and helping or making a way for women and youths in Nigeria to be gainfully employed (Oyebanji, *et al*. 2011)In addition, quality processing holds an opportunity of creating market for sweet potato tubers such as potato chips, potato flour and a lot of confectionaries which will encourage more rural farmers to go into sweet potato production, processing and marketing and invariably lead to increase in production, cost minimization and profit maximization.

Nigeria is one of the largest producer of sweet potato in sub-Saharan Africa with annual production estimated at 4.03 million tons per year with farm size of about 1.7mha and yield of 2.3t/ha (FAO, 2018). Sweet potato is an important food security and early maturity crop that can be intercropped with some crops like yam and maize. It can also be a mono-crop based on the intentions of the farmer. Sweet potato tubers are rich in starch, sugars, minerals and vitamins. Being rich in β-carotene, the orange- fleshed sweet potato (OFSP) is gaining importance as the cheapest source of antioxidant having several physiological attributes like anti-oxidation, anti-cancer and protection against liver injury and is most suiting as bio fortified crop to combat malnutrition in small and marginal farming community.

Skills are vital for an economy to grow and compete particularly in an era of economic integration and technological advancement. Training needs of rural farmers are very essential for the uptake of improved developed technologies for instance Training of rural farmers on value addition of Orange fleshed sweet potato in National root crops research institute Umudike. Training is a direct means of providing workers / farmers with the skills relevant to evolving needs of the economy. Interestingly skill development is an important factor in the drive to enhance OFSP production; processing and utilization which will stimulate economy raise people out of poverty and also ensure food nutrition security (Oguzor, 2017). New innovations are of little or no value unless they are put to use. Many sweet potato farmers are in dare need of training while some needs to be retrained on orange fleshed sweetpotato value addition that will help increase their diversification in sweetpotato production and avoid post-harvest losses. This study assesses the training needs of farmers on orange fleshed sweetpotato value addition in Abia state. The objectives were to describe the socio-economic characteristics of farmers in the study area and to assess the training needs of farmers on orange fleshed sweetpotato value addition in Abia state.

METHODOLOGY

The study was conducted in Abia State. The state has three Agricultural Zones with 38 extension blocks and 27 circles (ADP, 2004). It has a population of 2,833,999 made up of 1,234,193 males, 1,599,806 females, and a population density of about 578 persons per square kilometer. The three agricultural zones (Umuahia, Ohafia, Aba) of the state was involved in this study. A total of 120 respondents was randomly selected using multi stage stratified random sampling technique. One block in each zone was purposively selected because of their involvements in orange fleshed sweetpotato farming, giving a total number of three blocks. Four circles from each block was purposively selected for the same reason. Ten (10) orange fleshed sweetpotato crop farmers was randomly selected giving total of 120 farmers.

RESULTS AND DISCUSSION

Result from table1 shows that 11.67% of the respondent fell within the age range of 40-49, 31.67%were of the age bracket of 50-59 years while 43.33% of the respondent were in the age category of 60-69 years,13.33% were at the age of 70-79years. This implies that young people of active age (75%) dominated the production of sweetpotato in the study area. This findings is in agreement with Olagunji, Fakayode, Babatunde and Ogunwole-Olapade (2013) who noted that majority of sweet potato farmers in Osun State were in their active productive years.

On the sex of farmers, the result indicated that 49.2% were female farmers while 50.8% were male farmers. This implies that both male and females farmers were involved in sweet potato production on almost the same proportion.

Educational level of respondents indicated that 7.50% of the respondents had no formal education, 23.33% had primary qualifications while 42.50% had secondary qualification and 20.83% had NCE/OND, 5.8% had B.Sc/PG qualifications. This means that majority of the farmers were literate, as about ninety two percent of them had one form of formal education or the other. The high proportion of literate people among the farming population implies that majority of them are in a better position to be aware of, understand and adopt the sweet potato production and ultimately value addition technologies. Education also enhances farmer potential to process information and make the best out of any situation hence enable them to minimize risk and face uncertainties (Tura *et al*., 2010).

For household size, farmers that had between one to three people made up 10.83% of the respondents, those with four to six members constituted 46.67%, while those household with seven to nine persons constituted 42.50%. This means that the farmers had relatively large-sized households since they believe that getting married and having children is an alternative source of labour employed in sweet potato production.

For marital status, study findings showed that 21.7% of the respondents were single and 78.2% were married. This implies that majority of sweet potato farmers in the study area were married. This result concurs to the findings of Ejechi (2020) who found out that 78.1% of sweet potato farmers were married in Ebonyi state.

The result for farm size indicated that 29.17% of the respondents cultivated between 0.1-0.9 hectare, 45.83% cultivated between 1.0-1.9 hectares of farm land, 21.67% cultivated between 2.0-2.9 hectares while 3.33% cultivated 3 hectares and above. Majority of sweet potato farmers in the study area are small scale farmers because majority 67.5% of them cultivated between 1-3 hectares of land. This position is in agreement with the findings of studies by Ejechi (2020) who found small-scale farmers predominating the activities of sweet potato production in the Ebonyi state of south east zone of Nigeria. The result also corroborate with the findings of Omoare (2014) who stated that sweet potato farmers in Osun and Kwara states operated mostly on a small scale.

Table .1: Distribution of respondents according to their socio-economics characteristics

Socio-economic variables	Frequency	Percentage	Mean
Age			58.1833
40 – 49	14	11.67	
50 – 59	38	31.67	
60 – 69	52	43.33	
70 – 79	16	13.33	
Sex			
Female	59	49.2	
Male	61	50.8	
Education			10.4034
Non formal education	9	7.50	
Primary	28	23.33	
Secondary	51	42.50	
NCE/ND	25	20.83	
B.Sc./PG	7	5.83	
Household Size			5.8729
1 – 3	13	10.83	
4 – 6	56	46.67	
7 – 9	51	42.50	
Marital Status			
Single	26	21.7	
Married	94	78.3	
Farm size			1.1542
0.1 – 0.9	35	29.17	
1.0 – 1.9	55	45.83	
2.0 – 2.9	26	21.67	
3.0 and above	4	3.33	

Table 2 shows the results of ordinary least square regression analysis of the relationship between socioeconomic characteristics and training needs. The exponential function was selected as the lead equation based on the magnitude of the coefficient of determination, F-ratio and the number of significant variables.

From the result, the co-efficient of determination (R^2) of 0.753 entails that 75.3% of variations in training needs were explained by the socioeconomic characteristics under consideration, while 24.7% of the variations were attributed to error. The F-ratio of 4.029 which was significant at 1% significant level indicates the goodness-of-fit of the model.

From Table 2, age, farm size and education were significantly related to training needs. The coefficient of age (0.021) was positive and significantly related with training need at 5% level of significant. The implication is that the higher the age of the respondents, the greater their training needs. it could also be that older farmers have more experience in farming and are better able to assess the characteristics of modern technology than younger farmers, and hence a higher probability of adopting the practice. Teklewold et al (2006) found out that the older farmers have more experience in farming and adopt new farm practices more than the younger farmers.

The coefficient of farm size (-0.058) was negative and significantly related with training need at 5% level of significant. Implying that the larger the farm size of the respondents, the lesser their training needs. Farm size has a negative influence on value addition training. Increase in farm size reduces respondent's participation in values addition at five percent significance level. This can be attributed to the fact that those with large tracks of land devote large chunks to other competing enterprises such as maize which is considered a staple food in the area. This is contrary to Makhura et al (2001) findings that an increased area of land under cultivation stimulates participation in the market as it allows for an increased production extending beyond the consumption requirements. The findings further contradict Barungi and Maonga, (2011) findings that the fixed transaction costs decrease with an increase in farm size, which explains why the adoption of new divisible technology might begin with larger farms, secondly, because larger farms have a greater ability to raise capital, to bear the cost of the innovations and bear the risk of failure, they are likely to make risky investments compared to smaller farmers.

The coefficient of education (0.049) was positive and significantly related to training need at 5% level of significant. Implying that the higher the educational level of the respondents, the greater their training needs. Education level had a strong influence in the involvement in value addition training. The influence of education levels on technology uptake is well documented. Mishra, (2010) found that farmers with higher education have better access to information and knowledge that are beneficial to farming operation. They also tend to possess higher analytical capability of the information and knowledge necessary to successfully implementation of new technology and realize expected results. Hence, higher education allows farmers to make efficient adoption decision and be the early adopters who can take advantage of new technology and profit most from it.

Table 2: Ordinary least square regression estimates of the relationship between socioeconomic characteristics and training needs of respondents

Variables	Linear	+ Exponential	Semi-log	Cob Douglas
Constant	24.264 (19.504)***	3.192(52.891)***	26.965 (5.180)***	3.315 (13.037)***
Age	0.042(2.355)**	0.021(2.549)**	0.089 (2.070)**	0.064 (2.059)**
Sex	-0.096 (-0.306)	-0.003 (-0.197)	0.263 (0.651)	0.014 (0.705)
Farm size	-0.414 (-1.936)*	-0.058 (-2.029)**	-0.764 (-1.625)	-0.039 (-1.715)*
Marital Status	0.289 (0.713)	0.012 (0.605)	0.007 (0.013)	-0.002 (-0.087)
Education	0.018 (2.256)**	0.049 (2.445)**	0.853 (2.289)**	0.042 (2.298)**
Household Size	0.036 (0.498)	0.002 (0.580)	-0.724 (0.969)	-0.030 (-0.825)
R-Square	0.651	0.753	0.557	0.630
Adjusted R-Square	0.467	0.681	-0.346	0.449
F-ratio	3.988***	4.029***	3.785***	3.825***

HO Accepted at 5%

The figures in parenthesis are the t-values

***, **, * = significant at 1%, 5% and 10% respectively

+ = the lead equation

Table 3 shows that Flour (94.2%), (Orange fleshed sweetpotato drinks/juice (91.7%), Packaging (91.7%), Chips (89.2%), Skills for operating processing machines (89.2%), Flakes (86.7%), Meat Pie (85.8%), Selection of varieties for product processing (84.2%), are areas of training needs. However ranking the training needed shows that training on how to process orange fleshed sweet potato into flour, Drinks/ Juice and Packaging are the most training needs of the respondents in the study area. Therefore training needs of farmers targeted towards processing (Value addition) in the study area should be considered and the area of needs should be treated as the utmost priority.

Table 3: Distribution of respondents based on areas of training needed in OFSP value addition

Competences in Orange value addition	Highly Needed	Needed	Not needed	Mean	Std. Deviation
Skills for operating processing machines.	321 (89.2)	22 (9.2)	2 (1.7)	2.875	0.379
Selection of varieties for products processing.	303 (84.2)	36 (15.0)	1 (0.8)	2.833	0.357
Value added products processing					
OFSP (Drinks/Juice)	330 (91.7)	20 (8.3)	-	2.917	0.278
Flakes	312 (86.7)	28 (11.7)	2 (1.7)	2.850	0.322
Chips	321 (89.2)	24 (10.0)	1 (0.8)	2.883	0.301
Flour	339 (94.2)	12 (5.0)	1 (0.8	2.933	0.282
Meat pie	309 (85.8)	6 (5.0)	11 (9.2)	2.717	0.219
Packaging	330 (91.7)	14 (5.8)	3 (2.5)	2.892	0.181
Grand mean				**2.863**	

Note: The figures in parenthesis are the percentages, **source**: field survey 2020

CONCLUSION AND RECOMMENDATION

The study investigated the training needs of farmers on orange fleshed sweetpotato value addition in Abia State. The study reveals that most of the processors were female and the respondents were in their productive age. The most paramount training required by the respondents were Flour, Orange fleshed sweetpotato drinks/juice, Packaging, Chips, Skills for operating processing machines, Flakes, Meat Pie and Selection of varieties for product processing. It was recommended that more awareness creation, training programmes and provision of suitable and necessary incentive should be disseminated by government, nongovernmental organizations as well as research institution through extension agents should design programmes to train more sweetpotato farmers on how to process sweetpotato orange fleshed sweetpotato roots into flour , juice, chips and flakes for better returns.

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EFFECT OF CLIMATE CHANGE ON STORED PRODUCT PESTS: AN OVERVIEW

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ABSTRACT
The review examines the impact of climate change on stored product pest (SPP). Factors that contribute to the spread of SPP, the exposure to which they are subjected as a result of climate change and potential consequences of this exposure were reviewed. Climate change is of great concern to Agriculture globally and it is widely discussed presently and climate parameters such as temperature, relative humidity, atmospheric carbon dioxide (CO_2) and precipitation patterns have made significant impact on insect pests. The effect is evident in the increased prevalence of stored product pest by influencing the number of insect species colonizing stored products, development rate, survival, and wider geographic range due high temperature. These had led to increase in infestation rate thereby leading to serious grain damage and economic loss. A long term multi-disciplinary approach is needed to adhere to climate change, ensuring strategic adaptation and mitigation approaches over the unwavering impact of climate change on stored product pest.
Keywords: *Stored Products, Food security, Insect Pest, Stored Product Pests, Climate Change*

INTRODUCTION
Man overtime had engaged in an age-longed practice of preservation of essential commodities to meet different purpose at a particular period of time. These commodities constitute crop, animal and timber products and household goods. Stored agricultural produce is of significant importance being the staple diet of humans inhibiting different parts of the world (Lale, 2002). However, the overall goal for storage is to ensure adequate and consistent food supply (food security). Unfortunately, these stored grains are later infested with many insect pests. These insects are notorious and causes enormous damage to grains, pulses, and many other substances either directly or indirectly by consuming the seeds or seed products or by contaminating food products with their exuviae, cadavers and webbing (Mason *et. al*, 2012). Other sources of concern include accumulation of insect detritus thereby making stored products unfit or unhygienic for human consumption (Rajashekar *et al.*, 2012), boring of seed or grain kernels hence, destroying the germ portion and other several quantitative and qualitative losses (Ahmad et al., 2021). The storage pests often go unnoticed because they infest items that are not regularly used and also being very small in size may not be noticed easily. Storage pest such as weevils, beetles or moths seen flying in large numbers near stored items, or crawling over countertops, walls and ceilings, powdery residues below and surrounding stored items, and stale odours in pantries and closets are all possible indices of their presence and sign of infestation.

Climate change can have a significant impact on the behavior and life cycles of stored product pests, ultimately leading to potential consequences for stored goods. Generally, change in climate is a great concern to agriculture worldwide and it's among the most discussed issues in today's society. Climate parameters such as increased temperatures, relative humidity, rising atmospheric CO2 levels, and changing precipitation patterns have significant impacts on agricultural insect pests (Skendži´*et. al*., 2021). Studies have evaluated the effects of the mentioned atmospheric and climatic factors on the distribution, occurrence and abundance of field pests while areas of stored product pest have been more or less neglected. This has raised concerns because the main reason behind the occurrence of stored grain pests is the presence of favorable climatic condition for their growth and survival (Ahmad *et al.*, 2021).

Climate change continues to present challenges to life and livelihoods globally and amplifies the problems humankind is already facing (Altizer *et al*., 2013; IPCC, 2018). The focus of this paper is to outline the impact of climate change on stored product pest, considering the main drivers of climate change which significantly affect the population dynamics of insect pests and attendant losses and to suggest possible preventive, mitigation and adaptable approaches for SPP management in a changing climate.

Major Economic Stored Insect Pests in Nigeria

Common insect pest species that cause economic damage to stored agricultural products in Nigeria includes *Sitophilus* spp. (Coleoptera: Curculionidae), *Rhyzopertha* sp. (Coleoptera: Bostrichidae), *Trogoderma* sp. (Coleoptera: Dermestidae), *Callosobruchus* spp. (Coleoptera: Bruchidae; Chrysomalidae), *Tribolium* spp. (Coleoptera: Tenebrionidae), *Sitotroga* spp. (Lepidoptera: Gelechiidae), *Corcyra* sp. (Lepidoptera: Pyralidae), *Ephestia* spp. (Lepidoptera: Pyralidae), *Myelois* sp. (Lepidoptera: Pyralidae) and *Plodia* sp. (Lepidoptera: Pyralidae). Majority of SPP belongs to the order of Coleoptera and Lepidoptera that accounting for about 60 and 10 % respectively (Atwal and Dhaliwal, 2008).

The economic losses associated with Stored Product Pest

Stored product pests such as *Plodia interpunctella, Prostephanus truncatus* and *Sitophilus zeamais* are insects of economic importance in stored grains causing substantial losses if not properly managed (Ajayi *et al*., 2021; Kayode et al., 2021). These insect pests cause significant economic losses to crops, with population densities exceeding a pre-established threshold being the main culprit for such losses. For instance, the economic threshold for maize requires two *Cryptolestes ferrugineus* (Stephens), *Prostephanus truncatus* (Horn) per kg of grain while in a maize pest store 0.62 insects/trap/week is the (Economic Threshold Level) ETL for *Sitophilus* spp. (Toews *et al*. 2003). Even though control measures are often applied pre-emptively without considering economic levels, leading to unnecessary costs for farmers. However, determining ETL is important putting into cognizance the climatic factors that could influence serious pest infestation causing food shortages that lead to hunger. This will inform decision on appropriate measures for storage pest management practices which will minimize economic losses.

Impact of Climate Change on Stored Product Pest (SPP)

Generally, changes in climate can affect insect pests in several ways. They can result in an expansion of their geographic distribution, increased survival during overwintering, increased number of generations, altered synchrony between plants/grains and pests, altered interspecific interaction, increased risk of invasion by migratory pests, increased incidence of insect-transmitted plant diseases, and reduced effectiveness of biological control, especially natural enemies (IPPC, 2021).

According to Prakash *et. al* (2014) change in climate has both direct and indirect impacts on pests'; direct includes reproduction, development, survival and dispersal, whereas indirectly the climate change affects the relationships between pests, their environment and other insect species such as natural enemies, competitors, vectors and mutualists. Insects are poikilothermic organisms and undeniably temperature is the most important environmental factor affecting their behaviour, distribution, development and reproduction (Kocmánková et al. 2010).

So many stored pests have expanded their host range or distribution, at least in part globally due to changes in climate (IPPC, 2021). A typical example is the red palm weevil (*Rhynchophorus ferrugineus*) infestation on various palm species, which include coconut and date palm (El-Mergawy and Al-Ajlan, 2011). It was first detected on date palms stored and used for export in the Near East in the mid-1980s, and subsequently spread to other countries in the Near East, and to Africa and Europe (FAO, 2020). The distribution of the red palm weevil may expand because of climate change. Ge *et al.* (2015) predicted that in China the number of areas highly favorable to this pest would increase with climate change, resulting in the expansion of the insect into north China.

Effect of temperature on SPP

Temperature plays an important role in metabolism, metamorphosis, mobility, and host availability, which determines the possibility of changes in pest population and dynamics (Shrestha, 2019). It can strongly influence the life cycle and fitness of ectotherms of insects (Prakash *et. al* 2014). Ectotherms rely on external environment to regulate their body temperature and small changes in temperature can have dramatic effects on insects.

Due to increased temperature causing significant impact on crop pest populations in several complex ways, so also decreased temperature may tend to depress insect populations, although some researchers seem to agree that warmer temperatures in temperate climates will result in increased number of species and higher populations of insects (Lehmann *et al*., 2020). Higher temperature seems to be a double-edged sword as it enhances the multiplication of insects and also declines the efficacy of pesticides to certain insects (Prakash *et. al* 2014). Insect physiology is very sensitive to changes in temperature, and their metabolic rate tends to approximately double with an increase of 10 ◦C (Skendži´*et. al*., 2021).

Dukes *et al*., (2009) reported that increased temperature tends to accelerate insect food consumption, development and movement (distribution), which can affect population dynamics by influencing fecundity, survival, generation time, population size, and geographic range. Hence, this will increase grain damages and serious crop economic loss by the SPP because as temperature increases the insects respond in several ways - adapt, migrate and become cosmopolitan. Human activities in the environment have adverse influence to climatic conditions that apparently affects temperature of storage structures thereby determines the survival and distribution of stored product pest.

Effect of Relative Humidity on SPP

Relative Humidity (RH) influences insect growth and behavior by affecting their ability to regulate water loss (John, 2011). Warm humid condition is favourable for insect growth rate and development and RH in excess of 50% of stored grains especially improperly dried products, have tendency to absorb more moisture from the ambient air and become damp, thereby making it convenient for insect infestation (Lale, 2002). The damp environment influenced by RH is suitable for survival and distribution of stored product pest, as their physiology depends on atmospheric moisture (Patrick, 1982). Certain insects transfer themselves to regions of less evaporation when the air is dry, or when stored products proportion of water has been evaporated from their body. High humidity supports reproductive capacity in insects as percentage of water is correlated with the amount of fats (including eggs in female), which consists of anhydrous molecules and with the amount of cuticle, which has a lower water content than other tissues (Ahmad, *et al*., 2013). While low humidity is often detrimental to insect development, most insects found in desert have adapted to physiological and behavioral mechanism to prevent dehydration (John, 2011). In Nigeria, with warm and dry weather typically in February, March and April one can expect insect activities to increase.

Effect of Increased CO2 Concentration on SPP

Elevated concentrations of atmospheric CO2 can affect the distribution, abundance, and performance of insect pest. Such increases can affect consumption rates, growth rates, fecundity, and population densities of insect in grains or stored products (Fuhrer, 2003). Increased CO2 levels would have a greater impact on cereals especially, therefore, these differential effects of elevated atmospheric CO2 may result in asymmetric effects on stored grains and the response of insects feeding on them (Lincoln *et al*., 1984). Currently some available results suggest that the effect of elevated atmospheric CO2 on stored product pest is not only highly specific to individual insect species, but also to particular insect pest–host plant or grains (Coviella and Trumble, 1999).

Effect of rainfall pattern on SPP

Distribution, intensity and frequency of precipitation are very important indicators of climate change, it affects the incidence of pests directly as well as through changes in humidity levels (Pathak et al., 2012). This event threatens insect survival and affects their diapause but some SPP are found in cracks and crevices of buildings particularly in kitchens and tropical food stores as scavenging pests (Lale, 2002). Variable rainfall can have a major impact on insect populations. Unusual rainfall patterns with either delayed rainfall or early cessation of rainfall have great influence on insect pest resurgence, pest outbreaks and to some extent migration of this pest from one geographical region to another.

Prevention, Adaptation and Mitigation Approaches for Stored Product Pest Management in A Changing Climate

Preventive measure on the effect of climate change is one of the key components needed to maintain and preserve current and future food security. Although the ability to adapt to the impact of climate change through various pest management practices will depend on their physical, social and financial resources (Sutherst, *et al*., 2011). Increasing the ability to adapt rapidly to disturbances and present climatic changes is very important (Barzman *et al*., 2015). Potential adaptation strategies have been identified to reduce the risks of pest infestation and to mitigate the negative impacts of existing pests (Skendži´*et. al*., 2021). Adjustments in grain protection protocols, storage structures modifications are necessary because of recent climatic changes, but further adjustments will become increasingly crucial in the future, assuming the projected climate-change scenarios come true. Modified integrated pest management (IPM) practices are employed in monitoring climate and insect pest populations and the use of modeling predictions tools.

Grain Protection Protocols

Proper sanitation and handling of grains should be ensured during post-harvest operations prior to storage in order to prevent climatic implications that will enhance pest infestation leading to loss of crop products and economic damage (Howden, *et al*., 2007). Drying of grains after harvest to optimal range of moisture content is necessary. Temperature check and regulations should be practiced periodically, temperature below 13^0c slows development while high temperature above 35^0c stops development. In Nigeria, sun drying of infested chips is a major control method used by farmers to manage insect pests in stored agricultural products. However, this method presents several disadvantages. For instance, the sun drying method is the oldest known technique of conservation of agro-alimentary products, and it may not be effective in controlling all types of insect pests (Loko *et al*., 2013; Kayode *et al*., 2021). Additionally, sun drying may lead to product spoilage and decreased product quality because the high temperature damages the nutritional content and flavour of the product. Furthermore, the method is time-consuming and labour-intensive, making it expensive for farmers.

Modified Integrated Pest Management

Integrated pest management (IPM) decisions on the need for control measures should be based on the most modern tools, such as forecasting methods and scientifically validated thresholds. Direct pest control tools are the last resort when economically intolerable losses cannot be prevented by indirect measures (Boller *et al*., 2004).

Modified cropping practices and adaptive management strategies are needed to reduce the impact of insect pests on crops in a changing climate. Practicing the planting different crop varieties, planting at different times of the year to minimize exposure to pest outbreaks and increasing biodiversity at field margins to increase the number of natural enemies (Andrew and Hill, 2017). The use of pheromones and allelochemicals is an important method by which insects sense their environment. They play a substantial role in various IPM techniques such as biological control, mating disruption, push-pull strategies, monitoring and trapping (Heuskin *et. al*., 2011).

Monitoring Abundance and Distribution of SPP

One of the most important prerequisites for determining whether climate change is altering the population dynamics of insect pest species is access to long-term data (Yamamura *et. al*., 2006). Without these important baseline data, it is extremely difficult to fully assess changes in pest populations under changing climate regimes and also to predict future population dynamics (Andrew and Hill, 2017). Long-term monitoring of pest populations and behavior, particularly in climate change-sensitive regions, may provide some of the first clues to biological responses to climate change (Heeb *et al*., 2019). Changes in the dynamics of vectors, diseases and host populations at the local level need to be monitored, as do changes in their geographical distribution. New invasive species are being introduced in many parts of the world, aided by climate change. Effective monitoring and management systems are needed to prevent invasive species from becoming an economic pest in new geographic regions (Hellmann *et al*., 2008). Therefore, adaptive responses in both pest management and biosecurity will be required. Currently available pest management strategies such as detection, prediction, physical control, chemical control, and biological control could be intensified to control pests in response to climate change (Heeb *et al*., 2019).

Climate Forecasting and Model Development

Pest management strategies must tolerate regional climate change and its uncertainties. Some of the available options include sensitivity analyses and combined results obtained by using projected climate change scenarios with sensitivity analyses for a given area over a wide range of variable values. This strategy could become a useful tool in informing pest management personnel when designing adaptation measures for pest management under new environmental conditions (Sutherst, *et al*., 2011). Climate models combined with the environmental requirements of a particular pest species (envelope) can be an effective tool for projecting the possible range of changes on a global scale. Modelling the pest risk together with the responses of its plant hosts to climate change can therefore increase the ability to predict the outcome of an insect infestation (Fleming and Volney, 1995). A comprehensive analysis of climate and historical weather records, together with development of the models described above, will facilitate prediction of pest risks. This could be reflected in the development of proactive strategies for pest prevention and control strategies in a changing climate (Yonow *et al*., 2019)

Storage structures modifications

Modified hermetic or unventilated structures should be used for air-tight storage where oxygen is excluded for insect pest while the environment is monitored overtime. Elevator storage structures are modern facilities composed of large upright concrete bins, grain is moved from bin to bin using horizontal conveyor belts below the bins, a vertical bucket elevator to raise grain to the top of the elevator and spouting or another horizontal conveyor belt to carry grain to the new bin (David and Paul, 2014). According to Hagstrum *et. al.* (2013) the major stored pests *Rhyzopertha dominica* (F.), *Cryptolestes ferrugineus* (Stephens), *Sitophilus oryzae* (L.) and *Tribolium castaneum* (Herbst) in elevators in the USA were managed effectively with elevator equipment. Other improved storage structures such as Aluminum bin, Pusa bin, plastic and metal silos, Polyster polythene bags, jute bags etc (Reed *et al.*, 2003) were also reported to be effective in the management of such insects.

CONCLUSION AND RECOMENDATION

The effects of climate change on insects are complex while it favours such change in climate also inhibits others by negatively impacting on their distribution, diversity, abundance, development, growth and phenology. Researchers have evaluated the effects of several climatic factors – increased temperature, CO2, ozone or ultraviolet-B irradiation, and changing water or humidity patterns on insect pest. Therefore, it is generally expected that there will be an overall increase in the number of pest outbreaks involving a broader range of insect pests.

Despite the wealth of studies on climate-change biology, little have been documented on stored product pest, there are still prominent gaps in research into the impact of climate change on SPP. These gaps include the effect of climate change on the effectiveness of management strategies in stored-product entomology.

With climate change and the acceleration of global trade, uncertainties and frequency of occurrence of existing and new pests will increase. If climate change factors lead to favorable conditions for pest infestation and crop damage, then we will face a high risk of significant economic losses and a challenge to human food security. A proactive and scientific approach will be required to deal with this problem. Hence, there is a great need for planning and formulating adaptation and mitigation strategies in the form of modified IPM tactics, climate and pest monitoring, and the use of modelling tools.

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PROFITABILITY ANALYSIS OF POST-HARVEST MANAGEMENT OF TOMATOES IN KUDAN LOCAL GOVERNMENT AREA OF KADUNA STATE, NIGERIA

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ABSTRACT
About 40% of the crops that is cultivated in Nigeria never reach the market/consumers due to post-harvest losses. Therefore, every quantity of farm produce saved from post-harvest losses, usually translates to an added amount of food made available to the consumers. This study focuses on profitability of postharvest management of tomatoes in Kudan Local Government Area (L.G.A) of Kaduna State, Nigeria. Purposive and simple random sampling procedure was employed in selecting sixty (60) tomatoes farmers who adopted tomatoes post-harvest management techniques, and sixty (60) farmers who did not. Primary data were collected with the aid of structured questionnaire, and analyzed using descriptive statistics. Return on investment, net income and gross margin were computed. The results reveals that adopters of postharvest management practices incurred about 3.6% postharvest losses in tomatoes compared to those that did not (24.6% losses). Furthermore, a Net income of ₦1,177,200/ha and gross margin of ₦1,265,200/ha were realized by farmers who practiced tomato post-harvest management techniques, as against a net income of ₦743,900/ha and gross margin ₦814, 900/ha for those who did not. Also, for every ₦1 invested, a return of ₦1.60 was made by farmers that adopted postharvest management techniques as against a return of ₦0.98 made by those who did not. This shows that post-harvest losses reduce the returns of tomatoes farmers in the study area. Therefore, the study suggested that Nigerian Stored Products Research Institute with the mandate of post-harvest management, should sensitize the farmers on the importance of post-harvest management, and train farmers on the developed post-harvest management technologies.
Keywords: *Profitability, Tomato, Post-Harvest Management, Limited-resource-base, Return on Investment.*

INTRODUCTION
Food and Agriculture Organization (FAO, 2010), opined that the global efforts in the fight against hunger, low farmers income and food insecurity in the developing countries, should give priority to the issues of crop losses. This is due to the adverse effect of crop losses on food quality and quantity, and on the economic development in the developing countries. Thus, post-harvest losses have been identified as one of the major causes of food problems in most developing countries. Post-harvest losses include the rotting of produce and damage during storage, packaging and transportation which leads to consumer rejection (Adeoye *et al.,* 2009). It has been observed that post-harvest loses is much more painful and costlier than pre-harvest loss both in terms of money and man-hours. Adeoye *et al.* (2009) noted that the magnitude of the crop losses depends on the nature of the produce, the condition of the crop at the time of harvesting, the distance travelled, and the nature of the road networks the produce passed through before getting to the consumer.
Tomato which is one of the vegetables that are mostly cultivated in Nigeria is highly affected by post-harvest losses (Adepoju, 2014; Bello *et al.,* 2016). It belongs to the family of solanaceae and originated from the South American Andes. The fruit vegetable is a good source of vitamins and minerals that are essential for healthy human diet. Tomato is not only considered as food but as medicine, flavouring ingredient, nutrient supplement, human system cleanser, and detoxifier (Bello *et al.,* 2016). Tomato production in Nigeria has more than doubled in the last 10 years, being the most widely cultivated vegetable crop (Bello *et al.,* 2016). It is a relatively short duration crop. It is a high yielding crop with high economic benefits (Adepoju, 2014). It accounts for more than 18% of the total daily consumption of vegetables in Nigeria, making it a very important crop in Nigeria (Babalola *et al.,* 2010; Adepoju, 2014). Nigeria is ranked the 13th largest producer of tomato globally (FAO, 2010; Adepoju, 2014). Tomato is grown in the Southern part of Nigeria under the rain-fed systems, while it is grown under the irrigation systems in the Northern part of the country. Tomato is highly perishable in nature (Adepoju, 2014) with

limited shelf life due to its high moisture content. It is prone to pathological, physiological and mechanical damages (Adeoye *et al.,* 2009) as a result of the activities of insect pests, poor handling, rotting/deterioration which reduce the quality and quantity of the produce. Thus, farmers who have no means or facilities to process/preserve their tomato, tends to sell it off at a cheaper rate, which in turn reduces the net income of the farmers. Also, farmers who preferred to transport their produce to the market are faced with the problem of poor road network, and poor means of transportation which usually affect the produce's quality, price, and returns. However, one of the policy thrust of the Nigerian agricultural policy is to encourage farmers to adopt good post-harvest management, and to use on-farm and off-farm storage facilities that are simple and effective. Thus, this study aimed to analyze the profitability of post-harvest management of tomatoes under limited resource-base in the Northern Guinea Savannah Ecology of Nigeria.

METHODOLOGY

The study was carried out in Kudan L.G.A of Kaduna State. The State is located between Latitude 09° 02'N and 11° 32' N and between Longitude 06° 15'E and 08° 38' E. The average annual rainfall and humidity in the study area is 1,272.5 mm and 56.64 %, respectively. The average daily minimum and maximum temperatures are 15.1 and 35.18 °C (Saras, 2021).The State lies in northwest Nigeria and occupy about 5 % of the total land mass of the country with 46,053 km^2 of which 20,220 km^2 is arable. The major crops grown in the area are maize, sorghum, millet, rice, cowpea, pepper, potatoes, yam, tomatoes, leaves/vegetables, and sugarcane. Purposive and simple random sampling techniques were used to select the needed respondents for this study. Kudan L.G.A was purposively chosen for this study due to its peri-urban set up, intensive of tomatoes production, and good evidence of post-harvest management techniques employed by the tomatoes farmers in the area. A simple random technique was used to select 3 villages through balloting system, namely: Jaja, Hunkuyi, and Kudan villages. Then, a snow ball technique was used to identify the N_{ith} tomato farmers who employs post-harvest management techniques, and other i_{th} farmers in each of the villages. A list of $N_{i\text{-}nth}$ farmers who employs post-harvest management techniques was made, as well as those who do not. From this list, 20 tomato farmers who employ post-harvest management techniques and 20 who do not were purposively selected from each of the villages after focused group discussion, to give a total of 60 tomato farmers who employs post-harvest management techniques, and 60 who do not, making a total of 120 tomato farmers selected for the study. Primary data were collected through the use of structured questionnaire administered to the selected farmers. The collected data were analyzed using descriptive statistics such as mean, frequency, and percentage. Gross-margin, return on investments, and net income analysis were also computed.

Net income model

Net income is the difference between the gross return and total cost of farming as stated below

$$Net\ income = GR - TC \quad \ldots\ldots\ldots\ldots \quad (1)$$

Where GR = gross return (value of the useful/sold tomatoes in Naira) and TC = total cost of farming.

While

$$TC = FC - VC \quad \ldots\ldots\ldots\ldots \quad (2)$$

Where FC = fixed cost and VC = variable cost.

Returns on investment (ROI) model

$$Return\ on\ investment\ (ROI) = TR/TC \quad \ldots\ldots\ldots\ldots \quad (3)$$

Where ROI = Returns on investment,

TR = Total revenue in Naira, and TC = Total cost of tomato production in Naira.

Post-harvest losses (PHL) model

This is the differences between what is harvested from the farm and what is useful. It is stated thus:-

$$PHL\ (wasted/damaged) = TPH - TPU \quad \ldots\ldots\ldots\ldots \quad (4)$$

Where PHL = Post-harvest losses, TPH = Total products harvested from the farm at harvest.

TPU = Total products that is useful, that is, the ones sold out, gifted or consumed, the ones from which return is made.

$$\%PHL = \frac{PHL}{TPH}\ x\ 100 \quad \ldots\ldots\ldots\ldots \quad (5)$$

Where PHL and TPH are as stated above in equation 4.

Gross margin model

Gross margin model is expressed as follows:-

$$Gm = TR - TVC \quad \ldots\ldots\ldots\ldots \quad (6)$$

Where: GM = Gross margin, TR = Total revenue made by the farmer, TVC = Total variable cost.

RESULTS AND DISCUSSION

The socio-economic variables of the farmers were grouped into those farmers with Post-Harvest Management Techniques (PHMT), and those without. The results of the analysis are presented in Table 1. The result for age shows that 10% of the respondents are below 21 years, with 5.83% of them employing postharvest techniques to reduce losses, while 4.17% do not. About 32.5 percent of the respondents are 21 to 40 years old, out of which 14.83% employed PHMT, while 17.67% do not. The results reveal that a substantial proportion (46.67%) of the respondents were 41 to 60 years old. Of these, 22.67% employed PHMT, while 24% do not. The average age of the respondents was 43.6 years. This implies that most tomato farmers are within their active and productive age, and can be more flexible to new ideas and risk taking; and are more likely to adopt PHMT. This validates the assertion of Babangida (2016) who opined that youth are more in vegetable production. Table 1 reveals that 36.67% of tomato farmers in the study area were females, of which 28.33% employs PHMT, while 8.34% do not. Of the 63.33% of the respondents who were males, only 21.67% employs PHMT while 41.66% do not. This implies that female tomato farmers employ PHMT more than their male counterpart who dominated the tomato farming business. This is in line with Adepoju (2014) who observed that males dominated tomato production. The results in Table 1 further shows that 28.33% of the respondents had no formal education, while about 51.56% had secondary education, and a lesser percentage (2.5%) had tertiary education. A greater percentage (27.5%) of the farmers who employs PHMT had secondary education. This implies that they are better informed, and literate enough to adopt innovations. The average numbers of years spent in formal education by the farmers was 9. This validates the work of Saras (2021). The mean household size of the tomato farmers was 8, and 23.33% of farmers who employs PHMT have household sizes with 5 – 9 members. Also, the average years of farming were 12, with about 26.67% having farming experience of 11 – 15 years employing PHMT, while 22.33% do not. This implies that farmers with longer experience in tomato farming employ diverse means to reduce postharvest losses. About 33.33% of tomato farmers with land holding between 1 – 2.99 hectares employ PHMT, while 28.33% of them do not. The mean tomato farm size in the study area was 1.6 hectare. This implies that the tomato farmers are largely small holder farmers. Furthermore, Table 1 reveals that about 34.17% of the farmers do not have contact with extension agents, while 65.83% had, of which 43.33% employs PHMT, while 22.5% do not. Extension service is essential in the improvement of farmers' productivity and efficiency as stated by Muhammed (2015).

Table 1: Socioeconomics variables were group according to post-harvest management techniques (PHMT)

Variables	Frequency	Percentage	Mean	With-PHMT	Without PHMT
Age					
>21	12	10.00		5.83	4.17
21 – 40	39	32.50	43.6	14.83	17.67
41 – 60	56	46.67		22.67	24.00
<60	13	10.83		6.67	4.16
Sex					
Female	44	36.67		28.33	8.34
Male	76	63.33		21.67	41.66
Education					
No formal	34	28.33		11.67	16.67
Primary	21	17.50		9.17	8.33
Secondary	62	51.67		27.50	24.17
Tertiary	3	2.50	9	1.67	0.83
Household size					
1 -4	26	21.67		10.00	11.67
5-9	46	38.33		23.33	15.00
10 – 14	32	26.67		11.67	15.00
<14	16	13.33	8	5.00	8.33
Farming experience					
1 – 5	15	12.50		4.17	8.33
6 – 10	34	28.33		16.67	11.67
11 – 15	60	50.00	12	26.67	23.33
<15	11	9.17		2.50	6.67
Farm size					
> 1	17	14.17		7.50	6.67
1 – 2.99	74	61.67	1.6	33.33	28.33
3 and above	29	24.17		9.17	15.00
Extension Contact					
Had contact	79	65.83		43.33	22.50
No contact	41	34.17		23.33	10.84

Source: Field Survey, 2022.

Post-harvest management Techniques (PHMT) employed by the farmers in the study area.

Focused group discussion was used to source for information with regards to the various postharvest techniques that are employed by the tomato farmers in the study area. The discussion results showed that the various post-harvest management techniques adopted by the tomato farmers in the study area includes; harvesting at what they called "proper time" (when ripening process is setting in), gentle handling of fruits at harvest, use of vegetables crates in collecting the produce at harvest, sorting of fruits on the basis of firmness, sun drying fruits that have lost freshness or showing signs of spoilage, transporting produce in vegetable crates with van/pick-up to the central market for sales.

Profitability of Tomato Production among Farmers with and without PHMT

Return on investment, gross margin and net return analysis were used to ascertain the profitability of tomato production among tomato farmers with PHMT, and those without PHMT. The results of the analysis are presented in Table 2. Table 2 reveals that the total revenue obtained by the tomato farmers who employs postharvest management techniques was higher (₦1,912,000) than that of those who do not (₦1,504,000). Also, the gross margin of the farmers with postharvest management techniques is higher (₦1,265,200) than of those without postharvest management techniques (₦814,900). Likewise, the net return from tomato productions reveals that the farmers who employ postharvest management techniques obtained a higher return (₦1,177,200) than the ones (₦743,900) who do not. This implies that post-harvest losses reduce the net returns of tomatoes farmers in the study area. Table 2 further reveals that the return on investment is ₦2.60 among the farmers with postharvest management techniques, implying that for every ₦1 they invested in tomato production, a return of ₦2.60 kobo was made. While, the return on investment is ₦1.98 among the farmers who does not employs postharvest management techniques. Table 2 reveals also that the farmers who employs postharvest management techniques encountered 3.6% loss of their produce after harvesting, while the tomato farmers who do not, encountered 24.8% loss.

Table 2: Net Returns of Tomato production among farmers with and without PHMT

Variables/ operations	Quantity	With PHMT		Quantity	Without PHMT	
		Unit cost	Total cost		Unit cost	Total cost
Fixed cost (FC)						
Land rent	1 hectare	₦50,000	₦50,000	1 hectare	₦50,000	₦50,000
Depreciation	-	-	₦38,000			₦21,000
Total FC (TFC)	-	-	**₦88,000**			**₦71,000**
Variable cost (VC)						
Nursery/Seeds	3 cans of seed	₦7,000	₦ 21,000	3.5 cans of seed	₦7,000	₦24,500
Labour for nursery	21days watering	₦1,000	₦21,000	19days watering	₦1,000	₦19,000
Harrow/ridges making	10 man–day	₦5,000	₦50,000	10 manday	₦5,000	₦50,000
Transplanting	6 man–day	₦5,000	₦30,000	6 man–day	₦5,000	₦30,000
Farm management	12 days watering	₦8,000	₦96,000	13 days watering	₦8,000	₦104,000
Engine oil and petrol	3litre/watering	₦2,800	₦100,800	4litre/watering	₦2,800	₦145,600
Weeding	10 man-day	₦5,000	₦50,000	10 man-day	₦5,000	₦50,000
Pesticides	6 litres	₦5,000	₦30,000	5 litres	₦5,000	₦25,000
Spraying cost	-	-	₦20,000	-	-	₦20,000
Fertilizer						
NPK	3 bags	₦27,000	₦81,000	3 bags	₦27,000	₦81,000
Urea	2 bags	₦20,000	₦40,000	2 bags	₦20,000	₦40,000
Fertilizer application	3 man-day	₦5,000	₦15,000	3man-day	₦5,000	₦15,000
Harvesting	-	-	₦50,000	-	-	₦40,000
Transportation	-	-	₦ 42,000			₦ 45,000
Total VC (TVC)			**₦646,800**			**₦689,100**
Revenue						
All at harvest	248 baskets	₦8,000	₦1,984,000	250 baskets	₦8,000	₦ 2,000,000
PHL(Waste/damages)	9 baskets	₦8,000	₦72, 000	62 baskets	₦8,000	₦ 496,000
Total Sold out	239 baskets	₦8,000	₦1,912,000	188 baskets	₦8,000	₦ 1,504,000
% of loss	-		**3.6**			**24.8**
Total Revenue (TR)	**239 baskets**	**₦8,000**	**₦1,912,000**	**188**	**₦8,000**	**₦ 1,504,000**
TC = TFV + TVC	-	-	**₦734,800**	-	-	**₦760,100**
Gross Margin (TR-TVC)	-	-	**₦1,265,200**	-	-	**₦814,900**
Net Farm Return (TR –TC)	-	-	**₦1,177,200**	-	-	**₦743,900**
Return on Investment (TR/TC)	-	-	**₦2.60**	-	-	**₦1.98**

Source: Field Survey, 2022.

CONCLUSION AND RECOMMENDATION

The study which focuses on profitability of postharvest management of tomatoes in Kudan L.G.A of Kaduna State, revealed a net farm income of ₦1,177,200/ha, gross margin of ₦1,265,200/ha, return on investment of ₦1.60 for every ₦1 invested, and about 3.6% post-harvest losses for farmers with post-harvest management techniques, as against a net farm income of ₦743,900/ha, a gross margin of ₦814,900/ha, Return on investment of ₦0.98 for every ₦1 invested, and about 24.8% post-harvest losses for farmers without postharvest management techniques. Thus, the study concludes that post-harvest losses reduce the returns of tomatoes farmers in the study area. The study suggested that agencies like Nigerian Stored Products Research Institute (NSPRI), and others with the mandate of post-harvest management, should sensitize the farmers on the importance of post-harvest management, and train farmers on some of their developed post-harvest management technologies for proper adoption.

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POSTHARVEST LOSS MANAGEMENT IN SUB-SAHARAN AFRICA FOR FOOD SECURITY

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ABSTRACT
One of the main challenges facing the ever-growing world population is food security. The Food and Agriculture Organization (FAO) of the United Nations suggests that in order to feed the population, food production must increase by 70%. Nearly 1.3 billion tons of food production in the world is wasted as a result of poor postharvest management thereby posing food security threat. Developing countries experience more of postharvest losses; therefore, in order to achieve zero hunger by 2030, the problem of postharvest food loss must be addressed. Reducing post-harvest loss in Sub-Saharan Africa will not only increase the quantity of food available and overall access, but also alleviate poverty, increase agricultural productivity, and improve food utilization and safety in terms of health and nutrition, and reduce unnecessary resource use. Postharvest management strategies therefore need to be applied throughout the food and market value chains.

INTRODUCTION
Postharvest loss poses a serious challenge for food security and agricultural production in developing countries. In developed countries however, postharvest loss is characterized as a consumer behavior while in developing countries it is largely caused by financial, managerial and technical deficiencies (Conteh *et al.*, 2015, FAO, 2011, Premanandh, 2011). Consequently, in developing countries, food loss is mostly ex[rienced at stages 'close to the farm' such as production, handling, and storage (Lipinski *et al*., 2013, Parfitt *et al*., 2010, Premanandh, 2011). The problem of postharvest loss is more prevalent in Sub-Saharan Africa (SSA) where a great portion of the produce is lost as a result poor storage facility, lack of structured markets, limited processing capacity and weather-related factors (Affognon *et al*., 2015, Shiferaw *et al*., 2011, Tefera, 2012, Tefera *et al*., 2011). The global estimate shows that roughly one-third of the food produced for human consumption is lost or wasted FAO (2011). Postharvest loss in SSA is estimated to be about 37%, which is equivalent to an annual per capita food loss between 120 and 170 kgs (FAO, 2011, Sheahan and Barrett, 2017). In Eastern and Southern Africa alone, food losses are valued at $1.6 billion per year, which is nearly 13.5% of the total value of grain production (Abass *et al.*, 2014, World Bank, 2011). This evidence indicates that postharvest loss is a threat to the food and nutrition security and welfare of rural households.

Causes of Postharvest Losses in Sub-Saharan Africa

Employment of Improper Harvesting Methods: Majority of farmers in Sub-Saharan Africa are not exposed to proper and adequate education on advanced agricultural processes and tools. These therefore exposes them to the use of improper harvesting methods.

Lack of Access to Effective Storage Facilities: Many storage facilities in SSA are in poor condition, contaminated or infested with pests such as the larger grain borer, *Prostephanus truncatus* (Horn) or their capacity is inadequate to meet local production. This significantly contributes to the rate of post-harvest loss in Sub-Saharan Africa.

Absence of Proper Packing and Packaging Technologies: Fresh products in Sub-Saharan Africa are majorly transported in unpackaged form or tied in bundles. They are usually placed directly in the trucks and stacked up together, with no cushion against impact and compression. All these greatly reduce the shelf life of such produce if not sold quickly, and thereby contributes to Post-harvest loss in Sub-Saharan Africa.

Lack of Efficient Transporting System: According to a report by Institute of Food Technologists (IFT) wastage begins the moment growers leave their farms because their means for transporting crops are crude. This is frequent especially during the initial steps for getting them across the countryside to the locations where they can be staged for urban markets, all of which contributes to waste.

Unstable Climate Conditions: Climate factors, such as heat, humidity, and altitude, substantially increase post-harvest loss in Sub-Saharan Africa, as Africa is most vulnerable to climate change and its impacts. This contributes to postharvest loss (PHL) at all stages in the food supply chain from the moment of harvesting, to handling, storage, processing and marketing, as well as outside of the chain. Urgent and efficient climate actions are required to improve climate conditions and its impacts.

Strategies for postharvest management for food security

A systematic analysis of each commodity production and handling system is the logical first step in identifying an appropriate strategy for reducing postharvest losses. Also, a cost-benefit analysis to determine the return on investment in the recommended postharvest technologies is essential. It is important to select the technologies that are appropriate for the size of each postharvest enterprise. Marketing companies and cooperatives are essential for handling produce and reducing postharvest losses by providing facilities for accumulating, preparing and transporting produce to markets; by coordinating marketing activities; and by distributing profits equitably to members. Indicated an evolution of priorities within the postharvest sector of developing countries from a primarily technical focus geared towards the reduction of losses, to a more holistic approach designed to link on-farm activities to processing, marketing, and distribution. However, the major constraints continue to be high postharvest losses, poor marketing systems, weak research and development capacity, and inadequacies in policies, infrastructure, and information exchange.

Opportunities in Postharvest Management of Produce

Broad changes in Africa's food markets and value chains point to areas where new ways of operating can reduce food loss and waste.

• *Changing market demand*: Agricultural demand is rising in Africa, fueled by rapid urbanization and the growth of the region's middle class. Increasingly more prosperous and urban consumers are purchasing fruits and vegetables and processed and packaged foods. The production, processing, packaging, and distribution of these crops creates new income opportunities for smallholder farmers and rural people in general and particularly women. Fruit and vegetable production are also characterized by high losses and has high natural-resource intensity.

• *Sustainable local sourcing:* Many large corporations are seeking to make their supply chains more efficient by identifying cost-effective, reliable sources of local supply. Multinational supermarket chains as well as African local and regional entities are increasingly sourcing directly from local smallholders to meet domestic and export retail-related needs.

• *Smallholder participation in value chains:* Local sourcing activities represent an unprecedented opportunity to link farmers to more reliable and consolidated large-scale markets, as well as local ones. These links could generate market infrastructure within which postharvest loss could be more effectively addressed.

• *Loss-reducing technologies:* Many technologies for reducing food loss exist, but they are vastly underutilized. Examples include hermetic bags, heavy molded-plastic containers, and mobile processing units. These innovations have a small unit cost and are suited to individual use. These can also be, easily scaled up to meet growing demand. More complex solutions, such as cold storage, cost more, are better suited to multiple users and are less commonly used but can have a systemic impact under the right conditions.

• *Rising public and private investment in African agriculture, including postharvest loss:* African governments are prioritizing agricultural sectors such as horticulture (Kenya) and value addition to staple food crops (Nigeria). Other public and private organizations, such as the United States Agency for International Development (USAID), the Swiss Agency for Development and Cooperation (SDC), the African Development Bank (ADB), the Food and Agriculture Organization (FAO), the World Food Programme (WFP), and the Gates Foundation, are investing or exploring investments in postharvest activities. Large multinational companies have adopted sustainability goals linked to reducing food loss and waste.

CONCLUSION

Access to safe food remains a critical issue in Sub-Saharan Africa as a result of postharvest losses, which is projected to exacerbate as the Sub-Saharan African population is predicted to double by 2050. Despite the improvement in food production, post-harvest loss in the Sub-Saharan Africa remains an hindrance in the promotion of food security Postharvest technologies can contribute to food security in multiple ways. They can reduce PHL, thereby increasing the amount of food available for consumption by farmers and poor rural and urban consumers. Food availability and accessibility can be increased by increasing production, improving distribution, and reducing the losses. Thus, reduction of post-harvest food losses is a critical component of ensuring future global food security. Generally, significant role food loss reductions could have toward sustainably contributing to global food security.

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EFFECTS OF TRANSPORTATION SYSTEM ON INCOME OF MAIZE AND CASSAVA TRADERS IN OLUYOLE LOCAL GOVERNMENT, OYO STATE

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ABSTRACT
Transportation is a significant variable input in agricultural development all over the world because it is the only way to get produce and products from farm to market and vice versa. This study was conducted to evaluate the effects of transportation system on income of maize and cassava marketers in Oluyole Local Government Area of Oyo state, Nigeria. The data was collected via interview guide from 150 traders of maize and cassava who were selected through multistage sampling procedure. Descriptive (means and percentages) and inferential (regression) statistics were applied to the data collected. The study reveals that both maize and cassava traders were in their active age with mean age of 49 years. Majority of the traders were educated and married with family size of between 6 and 10 persons. The most popular modes of transportation in the study area were lorries, vans, taxis, and motorcycles. The regression analysis demonstrated that fuel shortages, transportation costs, mode of measurement, and low traffic volume were all significant at various levels and had a significant effect on traders' income. The biggest challenges for traders are fuel scarcity, insufficient vehicles, limited traffic volume, and expensive transportation costs. As a result, governments at all levels should support traders by finding solutions to fuel scarcity to facilitate the transportation of maize and cassava in the research study area.
Keywords: *Effect, Transportation, Maize, Cassava and Trader*

INTRODUCTION
Transport is regarded as an important factor involved in agricultural development all over the world. It is the only means by which food produced at farm site is moved to different homes as well as markets (Tunde, 2018). Transport creates market for agricultural produce, enhances interaction among geographical and economic regions and opens new areas to economic focus. There are complex relationships that vary both spatially and over time between transport and development. However, for any development to take place, transport plays a crucial role. Ogunsanya (2020) observed that there are three types of routes in the rural areas viz; bush paths, unsurfaced rural roads and surfaced rural roads. However, the bush path is very common but the least developed of all the routes. Bush paths link villages with farmsteads and they are usually narrow, winding and sometimes overgrown by weeds especially during the rainy season. In a study carried out by Filani (2019) in rural areas of Nigeria, it was discovered that where motorable roads exist they are mostly of unpaved surface, narrow width, circuitous alignment and with low quality bridges. In most cases, they are either clad with potholes or characterised by depressions and sagging. Such unsurfaced roads are hardly passable during the rainy season when vehicles get stuck in mud or when the improvised bridges of cut-tree trunks get swept away by flood. In another study carried out by Ogunsanya (2021) on relationship between transportation, underdevelopment, and rurality, he observed that the greater the degree of rurality, the lower the level of transport development. Aderamo and Magaji (2010) noted that transportation constitutes the main avenue through which different parts of the society are linked together. Paul *et al.*, (2009) pointed out that the impacts of road infrastructure on agricultural output and productivity are particularly important in Sub-Saharan Africa for three reasons: first, the agricultural sector accounts for a large share of Gross Domestic Product (GDP) in most Sub-Saharan countries (Paul *et al.*, 2009). Second, poverty is concentrated in rural areas; finally, the relatively low levels of road infrastructure and long average travel time's result in high transaction costs for sales of agricultural inputs and outputs, and this limits agricultural productivity and growth. According to Mabogunje (2019), some of the variables that determine the level of development in an environment are easy accessibility and mobility. This study investigated the following objectives: described the socio-economic characteristics of the farm-produce traders; identified the different

modes of transportation of farm-produce; examined the effects of transportation cost of maize and cassava produce on traders' income and identified the constraints faced by maize and cassava produce traders during transportation.

METHODOLOGY

The study was conducted in Oluyole Local Government Area (LGA) of Oyo state, Nigeria. The LGA is made up of 10 political wards divided into two sectors - Idi Ayunre sector and Olode sector. The Olode sector Comprises of ward 1 (Ayegun), ward 3 (Pegba/Egbeda tuba), ward 4 (Muslims/Ifelodun), ward 6 (Latunde) and ward 7 (Olomi/ Olunde). The major activities of the inhabitants is farming and trading. Oluyole Local Government produces virtually all farm produces such as pepper, tomato, maize, cassava, cocoa, cashew, banana, among others.

The population of the study comprised traders of arable crops in Oluyole Local Government Area of Oyo State. One hundred and fifty (150) traders were selected using multi-stage sampling technique. Data were collected using interview guide (structured questionnaire) and analysed using descriptive statistics (frequency, means, and percentages) and inferential statistics (regression analysis).

RESULTS AND DISCUSSION

Table 1 showed the socioeconomic characteristics of the respondents, average age of the respondents in the study area was 49 years and about 41% of the respondents were within their active working ages. Above average (63%) of the respondents were males. Majority (81%) of the respondents were married. It further showed that 42% of the respondents were Christian, 53.33% of the respondents were Muslim. It also showed that majority (90%) of the respondents were literates. It further revealed that 77% have household size of 6-10 members and this was the highest household size. However, all (100%) of the respondents engaged in trading.

Table 1: Distributions of Socioeconomic Characteristics of the Respondents.

Socio Economic Characteristics	Frequency	Percentage	Mean
Age (years)			
21-30	10	6.67	
31-40	17	11.33	
41-50	56	37.33	**49**
51-60	62	47.33	
61-70	5	3.33	
Gender			
Female	55	36.67	
Male	95	63.33	
Marital Status			
Single	11	7.33	
Married	122	81.33	
Separated	2	1.34	
Divorced	9	6.00	
Widowed	6	4.00	
Religion			
Christianity	63	42.00	
Muslim	80	53.33	
Traditional	7	4.67	
Educational Status			
No formal education	12	8.00	
Primary education	15	10.00	
Secondary education	123	82.00	
Family size (person)			
1-5	27	18.00	**8**
6-10	115	76.67	
11-15	8	5.33	
Years of Experience (years)			
5-15	42	28.00	**19**
16-	89	59.33	
26-35	12	8.00	
Above 35	7	4.67	
Primary Occupation			
Trading	150	100.00	

Source: Field survey, 2023

Modes of Transportation

Table 2 shows the frequency and percentage of farm-to-farm means of transportation of the respondents. Majority (90%) of the respondents used Lorries as a means of transportation from to farm while 69% of maize and cassava traders in the study area used taxis. This implies that taxis the common mode of transporting maize and cassava from farm to farmstead. It revealed that 32.67% of the respondents used Lorries for transportation from farmstead to village, 52.67% of the respondent used taxis from farmstead to village also 64.00% of the respondents used taxi from village to village. Lorries and taxi were used from village to town transportation at the rate of 45.33% and 49.33% respectively. It further showed 66.00% of the respondents used Lorries as a means of transportation from village to headquarter.

Table 2: Distribution of respondents on different transportation modes in the Study Area.

Types of Trips	Lorry F (%)	Van F (%)	Taxis F (%)	Motorcycle F (%)	Bicycle F (%)	Head porter age F (%)
Farm to farm	135(90.00)	5 (3.33)	6 (4.00)	4 (2.67)	0	0
Farm to farmstead	11 (7.33)	9 (6.00)	103(68.67)	23(15.34)	2(1.33)	2(1.33)
Farmstead to village	49(32.67)	14(9.33)	79(52.67)	8(5.33)	0	0
Village to village	32 (21.33)	17(11.33)	96(64.00)	5(3.34)	0	0
Village to town	68 (45.33)	7(4.67)	74(49.33)	1(0.67)	0	0
Village to head quarters	99 (66.00)	7 (4.67)	42(28.00)	2(1.33)	0	0

Source: Field Survey, 2023.

Table 3: Effects of transportation on traders' income

Source: Field survey 2023

Multiple responses

Key: F = Frequency, % = Percentage (values in parentheses)

Variables	Coefficient	Standard error	T	P>(t)	R^2
Maize					
Insufficient vehicle	-45501.83	43549.29	-1.04	0.298	
Low traffic volume	281235.8	82587.53	3.41	0.001**	0.45
Fuel scarcity	230769.3	39156.48	5.89	0.000*	
Transportation cost	24.97928	2.829042	8.83	0.000*	
Cassava					
Insufficient vehicle	-31094.18	19098.1	-1.63	0.106	
Bad road	41298.93	37467.24	1.10	0.272	0. 66
Mode of measurement	4841.311	444.8074	10.88	0.000*	
The cost from the farm	21.16802	14.07834	1.50	0.135	
Transportation cost	2.781495	1.492473	1.86	0.064***	
Fuel scarcity	77887.17	15530.21	5.02	0.000*	

Effects of Transportation on Traders Income

The result in table three showed the effect of transport-related variables on traders' income in the study area. The prob>F=0.0000 implies that the linear regression has a good fit for the linear regression. The significant variables for maize include low traffic volume (5%), fuel scarcity (1%) and transportation cost (1%). The significant variables for cassava include modes of measurement (1%), transportation cost (10%) and fuel scarcity (1%). A positive sign on a parameter indicates that the higher the value on the variable the higher the traders' income, similarly, a negative value of the coefficient implies that the higher the value of the variable the lower the merchant income.

Transportation cost was significant at 10% and positively related to merchant income, and the coefficient variable of fuel scarcity for cassava was significant at 1% and positively related to merchant income.

Constraint faced by the respondents during transportation of farm produce.

Table 4 revealed that maize and cassava traders were faced with problems of fuel scarcity in transporting farm produce as it ranked 1st. Insufficient vehicle ranked 2nd among the constraints faced by the traders in the study area. Similarly, low traffic volume, high cost of transportation, and bad road were ranked 3rd, 4th, and 5th respectively.

Table 4: Constraints Faced by the Respondents in Course of Transporting Farm Produce

Constraints	Strongly disagreed. F (%)	Disagreed F (%)	Undecided F (%)	Agreed F (%)	Strongly agreed F (%)	Rank
Bad roads	1(0.67)	0	0	2 (1.33)	147 (98.00)	5th
Insufficient vehicle	1(0.67)	19 (12.67)	2 (1.33)	118 (78.67)	10 (6.66)	2nd
High cost of transport	0	2 (1.33)	1 (0.67)	108 (72.00)	39 (26.00)	4th
Low traffic volume	1(0.67)	2 (1.33)	1 (0.67)	140 (93.33)	6 (4.00)	3rd
Fuel scarcity	0	9 (6.00)	54 (36.00)	62 (41.33)	25 (16.67)	1st

***Source*: Field Data, 2023**
Multiple responses.

CONCLUSION

The study reveals that both maize and cassava traders were in their active age with mean age 49. Majority of the merchants were married with medium family size of between 6 and 10 persons and they were also educated. The enterprise is not religiously biased because both Muslims and Christians were much involved with 19 as mean years of experience. The merchants were making use of lorry, vans, taxi and motorcycle as means of transportation, but bicycle and head portage were no longer in folk in the study area. The regression test showed that fuel scarcity, transportation cost, mode of measurement and low traffic volume were all significant at various levels and had serious effect on traders' income. The major constraints facing the merchants are fuel scarcity, insufficient vehicle, low traffic volume and high cost of transportation. Based on the above conclusions, it is therefore recommended that governments at all levels should assist the merchants by finding solution to scarcity of fuel and procure more vehicles to easy transportation of maize and cassava in the study area.

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PESTS INFESTATION OF STORED SMOKED DRIED FISH: A REVIEW

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ABSTRACT

A research on pest infestation of stored smoked dried fish was conducted to investigate the different types of pests causing damage to stored smoked dried fish and their levels of destruction. In Nigeria, fish is consumed fresh or processed (dried). Dried fish is one of the highly digestible and respectable sources of proteins and essential minerals but it is highly susceptible to insect pest infestation. Published papers on pest infestation of smoked dried fish, types of pests, economic importance of pests, microbial contamination and methods of controlling pests on smoked dried fish were reviewed. Pests commonly found on smoked dried stored fish are: flesh flies (Sarcophagidae), beetles (Dermestes, Cornestes, and Necrobia spp.), and mites (Lardoglyphus spp.). Feeding by larvae and adults of N. rufipes causes quantitative loss of dried cured fish, and also leads to fragmentation and to quality losses due to contamination by insect bodies. Dermestes spp accounts for about 71.5% of dried fish infestation recorded in most of the producing areas with a substantial loss in dry weights of about 43-62.7% from both larvae and adu1ts.). At 6weeks of storage, adult Necrobia spp infested 31% of stored smoked Tilapia spp and 80% of Synodontis spp. Infestation of dried smoked fish by insects and mites may cause public health hazard as they are transmitters of diseases causing pathogens to man that my lead to intestinal disorders and allergies. Pests also causes economic losses to fish mongers and are a threat to them reducing the nutritional, and economic values of the product, therefore the need for this review. It is recommended that fish be salted and dried properly to minimize infestation by pests in order to lengthen its shelf life. Also, fish processors should be educated by extension workers on personal hygiene while handling fish as a measure of reducing contamination with blow flies and other micro-organisms.

Keywords: *Pest, Infestation, Stored, dried and Fish.*

INTRODUCTION

Fish provides an excellent source of protein in the diet of many families in tropical Africa. Of all the animal protein foods produced and consumed in Nigeria, fish is of prime importance as it has remained a major source of protein which is rich in essential-amino acids for both rural and urban poor households. The fish is rich in protein, which is very essential for the health of the body and it account for about 40 percent of the total animal protein of an average person in the tropics (Olatunde, 2003; Reed *et al.*, 2009). Fish is rich in fats, and the following minerals: phosphorus, sulphur, potassium, iron, calcium and copper. Fish fat is characterized by high poly-unsaturated fatty acids, which provides diet low in cholesterol. Its oil has high quantities of vitamin especially vitamin A, B and D, thiamin, riboflavin, nicotinic acid and vitamin B12. Fish contains less than 1% fat and about 10% protein with energy value ranging from 220 – 330 Kilojoules (50 – 80 Kcal/100g) of fish. In Nigeria, fish is consumed fresh or processed (dried) (Horn, 1974).

Dried fish is a highly favoured item of many traditional dishes in Nigeria because of its high proteinous content which is more than fresh fish and other animal proteins like egg, meat and milk. Dried fish is often a good alternative to fresh fish which is readily available in many inland communities because of improved transportation, preservation methods along with growth in inland aquaculture (Eke *et al.,* 2008).

Drying is one of the most popular means of preserving and storing fish. However, drying of fish does not guarantee the ends to the problems of preservation, storage and distribution of fish. Dried fish can suffer considerable loss of weight due to feeding damages caused by insects and mites. Under adverse condition quantitative losses of up to 30 % due to fly damage during processing and up to 50% due to beetle damage during storage have been reported (FAO, 1989).

Some factors responsible for this spoilage or damage includes high temperature, chemical action, enzymes and bacteria (Ojutiku *et al.,* 2009; Oparaku and Mgbenka, 2012). Processing and preservation methods slow down fish spoilage, preserve its quality and also extend fish shelf life (Okonta and Ekelemu, 2005). Several processing and preservation methods have been considered and used to prevent fish from spoilage, including: salting, sun drying, solar drying, smoke drying and canning (Ugwu *et al.,* 2005). The most common method of fish preservation employed in the tropics is smoking; it increases fish shelf life, gives the product a desirable taste and odour, it also provides antibacterial and oxidative effects, lowers pH, imparts colouration as well as accelerates the drying process and acts as an antagonist to spoilage agents (Akintola *et al.,* 2013).

Stored product insects are known in different agricu1tural products including smoked fish products). It was noticed that good storage practices are not observed by most fish-sellers of smoked and smoke-dried fishes such as improper ventilation and easy access of pest into the storage environment (Sani et al., 2016) A number of authors (Nowsad *et al.,* 2009; Babarinde *et al.,* 2012; Lithi *et al.,* 2012; Onyuka and Ofulla, 2013; Zakka et al., 2013) had reported the menace of insect pest infestation on stored smoked fish. Awoyemi (1991) examined the storability of different fish species over a period of 60 days and observed that they were reduced to mere Fras and bones by *Dermestes macu1atus*. The genus *Dermestes* are known for their infestation of dried fish causing qualitative and quantitative damage. The need to protect smoked fish from pests is imperative when the fact that fish plays the crucial role in ensuring food security, income generation and employment opportunities are considered. The large dependence on imported fish can adversely affect the economy (mostly foreign reserves) of some developing countries.

A number of insects infest processed fish but the most important fall into two groups the blowflies and beetles. Insect flies and beetles destroy vast quantity of fish in developing countries while it is being processed or stored (Johnson and Esser, 2005). Insect infestation of cured fish by blowflies and hide beetles is an important cause of post- harvest fish losses in many developing countries like Nigeria. Fish are susceptible to attack by insect pests throughout processing and storage (Reed, 1997). Under prevailing conditions, it is estimated that between 25% and 75% of the nutritional value of fish is lost during attack by insect pests, (Johnson and Esser, 2005). Dried fishery products frequently suffer severe losses due to infestation by flesh flies (*Sarcophagidae),* beetles (*Dermestes*, *Cornestes*, and *Necrobia spp*.), and mites (*Lardoglyphus* and *Lyrophagus s*pp.) (Venugopal *et al*., 1999). These infestations are heavy in dried products containing 7–21% salt and stored under tropical conditions, at 20–32◦C and air humidity of 73–87%. Based on a conservative estimate, the loss represents about 2.75 mt of dry fish for a year in all over the world (Gopakumar and Devadasan., 1982., Wood., 1982) large quantity of dried fish is lost in India due to infestation by earwig, hide beetles, and copra beetles. The most destructive pest is the hide beetle*; Dermestes maculatus*. Infestation of sun-dried fish by the blowfly and beetle larvae caused up to 30 percent loss of the products (Bala and Mondol., 2001; Nowsad., 2005). Dried fish contaminated by both insects and harmful insecticides comprises about 80 percent of the total dried products that is considered unfit for human consumption. The losses have been attributed to net reductions in the amount of nutrients available to the consumer (nutritive quality) resulting to declining consumer acceptability and market prices (economic losses) or both quantitative and qualitative losses (Odeyemi*., et al.,* 2000., Atijegbe., 2004). This study is aimed at investigating the different types of pests causing damage to smoked dried fish and their levels of destruction.

Economic importance of pests

Losses caused by insect infestation are enormous. They include physical loss, whereby the fish available for human consumption is reduced, economical loss where by the physical loss depletes the quantity of fish available for sale, and nutritional loss which is the direct consequences of the physical and economic losses and cause the retail value of fish to increase beyond the purchasing power of the poor (Moses, 1992).

FAO (2019) also reported that insects infest smoked dried fish during storage and cause economic loss to fish mongers and loss in the qualitative and quantitative composition of the fish. Infestation of dried fish by insects and mites may cause public health hazard as they are transmitters of diseases causing pathogens to man that may lead to intestinal disorders and allergies (Busvine, 1980; Osuji, 1985). Furthermore, flies which often perch on dried fish have been implicated as vectors of pathogens causing severe enteric disorders such as dysentery, cholera e t c (Busvine, 1980). Insect pests invade the fish at different stages of processing and storage thereby destroying it (Johnson and Esser, 2005), adult *Dermestes* and *Necrobia* can fly and are thus easily dispersed to new sources of food where they cause food damage, and their infestation also predisposes the infested fish to microbial attack (Adedire and Lajide, 2000).

Types of pests and their levels of destruction

The pests commonly found on dried fish are flesh flies (*Sarcophagidae*), beetles (*Dermestes, Cornestes*, and *Necrobia* spp.), and mites (*Lardoglyphus* and *Lyrophagus spp*.) (Harines., 1989).

Necrobia rufipes: is a beetle of the family *Cleridae* and is the commonest species of *Necrobia* found on cured fish. Two related species, *N. ruficollis* and *N violacea*, are only rarely found on this commodity (Harines., 1989). Feeding by larvae and adults of *N rufipes* causes quantitative loss of dried cured fish, and also leads to fragmentation and to quality losses due to contamination by insect bodies and cast skins. The extent and value of losses due to *N rufipes* infesting dried fish have not been assessed either in the laboratory or the field, but they will of course be directly related to the length of storage of the fish. When associated with *Dermestes* infestations, *N rufipes* is usually in the minority but its contribution to the total beetle damage may be significant (Harines., 1989). At 6weeks of storage, adult Necrobia spp infested 31% of stored smoked Tilapia spp and 80% ofSynodontis spp. (Wahedi and Kefas, 2013). Eyo (2001) reported that long storage periods allow insects more time to breed and consume stored fish, thus leading to ever increasing infestation.

***Dermestes* Species:** belong to the beetle family *Dermestidae*. Several species have been recorded infesting dried fish*: D. maculatus, D. frischii, D. carnivorus Fabr, D. lardarius, D. haemorrhoidalis*, and *D. peruvianus* . Feeding by the larvae and adults of *Dermestes* spp. Causes considerable quantitative loss of dried cured fish, and also leads to fragmentation. (Harines., 1989). According to Uneke (2015) the well-developed mouth parts of adult *D. maculatus* gives them a more destructive tendency than the larvae. The extent and value of quantitative losses caused to dried fish by *Dermestes* spp. have been assessed by various investigators, and estimates range from negligible up to 50% weight loss, depending on length of storage, salt content, moisture content, climatic conditions, and general hygiene during processing and storage. *Dermestes spp* accounts for about 71.5% of dried fish infestation recorded in most of the producing areas with a substantial loss in dry weights of about 43-62.7% from both larvae and adu1ts (Babarinde *et al*., 2012).

***Lardoglyphus Species*:** belong to the family *Acaridae* in the mite group Astigmata. Three species have been found infesting cured fish: *L. konoi*, *L. zacheri and L. angelinae*. Feeding by the adults and nymphs of *Lardoglyphus* spp. will cause quantitative loss of dried cured fish. Quality loss may result from the contamination by live and dead bodies, which can be very numerous. The extent and value of losses caused to dried fish by *Lardoglyphus* spp. have not been assessed in either the laboratory or the field (Harines, 1989).

***Diptera*:** Most flies found on cured fish belong to the subfamilies *Calliphorinae* and *Sarcophaginae* in the family *Calliphoridae.* The commonest of these are various species of *Chrysomia*, but *Calliphora, Lucilia, Sarcophaga* and *Wohlfartia* have also been reported (Harines, 1989). Other families represented in records of flies infesting cured fish are: *Muscidae, Piophilidae, Milichidae, Phoridae* and *Ephydridae*. All these flies are rather similar in general form, though they show a variety of size and coloration, and their identification requires specialist knowledge (Harines, 1989). The feeding of the larvae of *Calliphoridae* on moist fish causes quantitative losses. These losses can be severe if conditions are optimal for fly development: under such conditions, i.e., if unsalted or poorly salted fish is dried slowly because of rain or high humidity, weight losses of 10-30% can be caused by fly larvae. Fragmentation of the fish by fly attack can cause quality loss and may lead to increased risk of damage by beetles and mites. Substantial weight losses due to fragmentation of fish during processing have been recorded, but the contribution of blowfly damage to this has not been separately assessed. Additional costs are implicated in the role of flies as the agents of myiasis and as carriers of pathogens (Harines, 1989).

Microbial contamination

Smoked dried fish are often contamination with microorganisms such as fungi, bacteria, yeast and moulds (Sani, et al., 2016). Saprolegnia is the most important fungal contaminant of fish, although a number of other species have been implicated (Sani, *et al*., 2016). Martin (2008) stated that bacteria (*Staphylococcus aureus*),yeasts (*Saccharomyces cerevisiae*) and moulds (*Penicillium* and *Aspergillus*) are the commonest microorganisms associated with smoked dried fish.

Pathogenic fungi that contaminate fish during processing can also cause considerable hazard to consumer health (Yijia *et al*., 2020). Banwart (2004) also observed that most of the post processing microbial contaminants originate from poor handling practices, while some could be from the air, the source of the fish, or from other degrading substances (Ayuba, *et al*., 2013).

Control of pests

Because of the obvious food, economic and health implications of beetles in smoked fish, several attempts have been made to control them. The major pests on smoked catfish, *Clarias gariepinus* include *Dermestes maculatus* (hide beetle) and *Necrobia rufipes* (copra beetle) which could be controlled by synthesized chemicals. However, there have been Increasing and concerted efforts directed at developing natural pest management control agents that are relatively cheap, safe, biodegradable and environment friendly as alternatives to synthesized insecticides (Mabawonku and Ajayi, 2007).

Development of *Dermestes maculatus* is not possible at 40^0C or above, because, temperature above 40^0C can kill or repel all these beetles. Such temperature can disinfect fish or delay invasion by *Dermestes maculatus* as long as it is achieved throughout the batch. If some of the fish remains at normal temperatures, the beetle will migrate.

Well-dried fish reduces the rate of *Dermestes* population growth. Salting of fish gives protection against *Dermestes maculates*, partly because larval development is prolonged and larval mortality increases with increase in salt content. In experiments at 30^0c, larval development took 37 days on fish with 3.5% salt content compared with 211 /2 days on unsalted fish and mortality reached 100% when the salt content was increased to 9.2% by brining for 11 /2h (Osuji, 1975). This susceptibility to salt may explain the less frequent occurrence of *Dermestes maculatus* in cured marine fish, as salt is more commonly used in marine fish processing. Ashamo and Ajayi (2003) recommended the use of paper cartons and aluminium foils as good packaging materials but the authors noted that any tiny hole in the plastic or foil through which a flow of air can pass will nullify its effectiveness, as insects can pass in and be sustained on the stored fish. Cold treatment or freezing of dried fish at $6\text{-}12^{oc}$ can kill all developmental stages of insects (Boeke *et al.,* 2001) but unreliable electricity supply or lack of the purchasing power makes the use of refrigerator undependable in poor resource-based communities. In addition, mouldiness, rancidity and texture sponginess of such frozen fish have been reported (Ashamo and Ajayi, 2003). The use of contact insecticides is extremely effective against insect infestation, but it is only justified under approved and controlled conditions.

Insecticides are highly toxic and many are dangerous. Only a few are safe to use on foods. One of safe substance is pirimiphos methyl and this has been approved internationally for use on fish. It is extremely effective in controlling blowfly attack during fish drying. When used under specified conditions, it leaves no harmful residues. Pirimiphos methyl is also effective in controlling beetle infection during storage (Khan and Khan, 2002). The uses of plant materials for insect pest control have been reported to be important materials for the control of smoked fish pests. Among the plant materials reported include; Citrus peel oil (Donpedro, 1985), Eugenia aromatica (Akinwumi *et al*., 2006), *Piper guineense, Monodora myristica* and *Tinolia diversipolia* (Fasakin, 2003). Plant-derived materials are more readily biodegradable, less toxic to mammals, retard the development of resistance, easy and cheap to produce by farmers and small-scale industries as crude, or partially purified extracts. It was reported that when dried fish was mixed with leaf bark, seed powder, or oil extracts of selected plants, there was mortality of beetles, reduced oviposition rate, suppression of adult emergence and reduced fish damage rate (Okorie *et al*., 1990; Adedire and Lajide, 2000; Okonkwo and Okoye, 2001; Fasakin and Aberejo, 2002; Anyaele and Amusan, 2003

SUMMARY/RECOMMENDATIONS

Pests that commonly infest smoked dried fish on storage are: beetles (*Dermestes, Cornetes* and *Necrobia* spp.); mites (*Lardophagus spp* and *Lyrophagus spp*) and *Diptera* (flies). These pests cause quantitative loss of dried cured fish and also leads to fragmentation and to quality losses due to contamination by insect bodies, they also cause physical loss where by the fish available for human consumption is reduced, economical loss where the physical loss depletes the quantity of fish available for sale, and nutritional loss which is the direct consequences of the physical and economic losses and cause the retail value of fish to increase beyond the purchasing power of the poor. It is recommended that fish be salted and dried properly to minimize infestation by pests in order to lengthen its shelf life and fish processors be educated by extension workers on personal hygiene while handling fish as a measure of reducing contamination with blow flies.

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PERFORMANCE ANALYSIS OF THE CASSAVA PRODUCERS AND PROCESSORS IN ABIA STATE, NIGERIA

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ABSTRACT
The study analyzed the performance of the cassava producers and processors in Abia State, Nigeria. A multi-stage random sampling procedure was used to select 120 cassava producers and 120 cassava processors making it 240 respondents. Primary data was collected with the use of a structured questionnaire. Data collected were analyzed with descriptive statistics such as frequency, percentage and table, and also cost and returns model. Results showed that the majority of the cassava producers (53%) and (51%) of cassava processors were males. The cost and returns result shows that variable costs accounted for a very large proportion 96% of the total cost of cassava production and 99% for cassava processors. The study therefore, recommends that farmers especially women should be encouraged to grow and process cassava to improve on their livelihood and standard of living as their incomes would have increased. They should also be encouraged to form more cooperatives in order to enjoy credit facilities, increase their performance in cassava production and make high profit in the cassava business.
Keywords: *Performance analysis, cassava producers, processors*

INTRODUCTION
Agriculture provides a living for approximately 70% of Sub-Saharan Africa's rural poor (Moono, 2015). According to Adeoti *et al.* (2014), agricultural expansion is twice as effective as other sectors in reducing poverty. However, primary producers cannot add value to their products due to socioeconomic, environmental, and technological constraints. As a result, low manufacturing efficiency and product diversification has been limited. Furthermore, farmers' insufficient capital development may have hampered farm and household revenues. Cassava production and marketing are difficult for smallholder farmers. This could help smallholder farmers overcome obstacles along the cassava value chain. According to Achem *et al.* (2013) and Abu *et al.* (2014), cassava root processing and value addition are required to extend shelf life (rots within 3-4 days of harvest), improve nutritional content (low in other nutrients, particularly proteins), and convert cassava root into other goods (FAO, 2005). Despite farmers' difficulties in reaching markets, few studies on analyzing the performance of cassava producers and processors in Nigeria have been conducted. Therefore, the specific objectives of the study were to describe the socio-economic characteristics of cassava producers and processors in the study area; to determine the performance of the producers and processors regarding their cost and returns in Abia State.

METHODOLOGY
This study was carried out in Abia State. Latitudes 4°, 41', and 6°, 14' north of the Equator, and Longitudes 7°, 10', and 8° east of the Greenwich median, roughly define the state. This study's population included all cassava producers and processor for market. The respondents for the study were chosen using a multi-stage sampling technique. First, one local government area from each of the three agricultural zones was chosen. Four autonomous communities were chosen from each of these local government areas giving twelve communities. Two villages were chosen from each selected communities, and his takes it to 24 villages. Ten cassava farmers producing for market and ten cassava farmers processing for market were chosen from these villages, resulting in a total of 120 producers and 120 processors. As a result, 240 respondents were used in the study. The primary data were collected directly from the field survey using structured questionnaires. In the data analyses, simple descriptive statistics such as tables, means, frequencies and percentages were used to achieve objective , while cost and returns model was used to analyzed objectives 1 and 2. The cost and returns model is given as:

$$NR = TR - TC \quad .... (1)$$

Where:

NR = Net Returns (₦)
TR = Total Revenue (returns) from the cassava enterprise
TC= Total Costs (₦)
N/B: TC = TVC + TFC
TVC = Total Variable Cost; TFC = Total Fixed Cost
N/B: Equation 1 was analyzed for both cassava producer and processors.

RESULTS AND DISCUSSION

Socio-economic characteristics

The result in Table 1 showed that the majority of the cassava producers (53%) were males while processors had 51% males Generally, it can be deduced that cassava production and processing has little gender bias in the study area against the conventional idea that cassava-based activities are female-dominated (Awerije, 2014 and Amadi *et al*., 2018). The result showed that the majority (47% and 61%) of the cassava producers and processors, respectively, were 41–50 years. The mean age of 46 and 47 years for the cassava producers and processors implies that the respondents are still young, energetic, and in their active years. The result showed that majority (60% and 58%) of the cassava producers and processors respectively had about 4 – 6 persons in their households. This implies that the marketable surplus is obtained with small family sizes, which is not possible in large family sizes where most of what is produced is consumed. The result also showed that 50% and 73% of the cassava producers and processors, respectively, had secondary education. This finding is consistent with Ajok (2016). In addition, the result revealed that 50% and 73% of the cassava producers and processors, respectively, had secondary education. A mean of 12 and 14 years for producers and processors suggest that processors received higher education than producers. Using some machines for processing may require a higher level for their operations (Oni, 2016). The results also indicated that participation in cooperative activities was minimal for both cassava producers (11%) and processors (12%). Cooperatives are very important as they serve as catalysts for several benefits. The computed results also showed that more producers (58%) had access to market information than processors (38%). This is not expected because the producers are only limited to the sales of tubers which in most cases are done at farm gate level, unlike the processors who have a variety of products to sale.

Table 1: Some selected socio-economic characteristics of respondents

	Cassava producers		Cassava processors	
Variables	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Gender				
Male	64	53	61	51
Female	56	47	59	49
Age of farmers (Years)				
21 – 30	2	2	3	3
31 – 40	36	30	17	14
41 – 50	57	47	73	61
51 – 60	16	13	23	19
61 – 70	9	8	4	3
Mean	**46 years**		**47 years**	
Household size				
1 – 3	34	28	32	27
4 – 6	72	60	70	58
7 – 9	14	12	18	15
Mean	**5**		**3**	
Years of education				
1 – 10	41	34	13	11
11 – 20	56	47	74	63
21 – 30	11	9	31	26
Mean	**12 years**		**14 years**	
Cooperative membership				
Yes	13	11	14	12
No	107	89	106	88
Access to market information				
Yes	70	58	46	38
No	50	42	74	62
Total	**120**	**100**	**120**	**100**

Source: Field survey, 2020

Performance analysis of the cassava producers

The entries in Table 2 shows that cuttings accounted for about 42.4% of the total cost of production of cassava in the study area, followed by fertilizer (34.3%) while labour (8.4%) was the least. It is well known that cassava production is labour intensive. However, the lower cost incurred from labour may be related to the utilization of household members in farm activities, while hired labour was for augmenting the family labour. In general, variable costs accounted for a very large proportion (96%) of the total cost of cassava production. Fertilizer utilization in the area of study is generally high, either because of the importance of fertilizer in increasing yield or due to the poor nature of the soils because of continuous use. Agrochemical use is moderate, probably because of the disease resistant nature of the varieties planted.

Table 2a: Performance analysis of the cassava producers

Cost items	Amount (₦)	Percentage
Variable costs		
Stem (₦)	61381.67	42.4
Fertilizer (₦)	49716.67	34.3
Agrochemicals (₦)	15350.27	11.0
Labour (₦)	12206.46	8.4
Total variable cost (TVC)	**138655.28**	**96.0**
Depreciation (₦) **(TFC)**	6164.58	4.0
Total cost, TC = TVC+TFC	**144,819.86**	
Quantity sold (kg) (Q)	8155	
Average price/kg (₦)	80	
Total Revenue, TR = (Q*P)	652,400	
Profit (TR – TC)	**507,580.14**	

Source: Field survey, 2020

Performance analysis of the cassava processors

The result on the cost and returns in processing as reflected in Table 2b showed that roots accounted for about 59% of the total cost of processing. In a similar study conducted by Achem *et al*. (2013), the authors noted that cassava root cost took the largest percentage of the total processing cost. Labour costs about 16% of the total processing cost. The second key element that needed huge investment in cassava processing, as noted by Ajok, 2016 was the element of labour. Costs comprising the labor component are one of the most important contributors to the total production costs in cassava processing. Depreciation cost was only 1% of the total processing cost. This implied that although cassava processing needs huge capital investment in the processing equipment at the initiation of the enterprise, however, once established, processors normally operate at optimum level hence enjoying the economies of scale. The economies of scale enable processors to enjoy better prices (Saediman *et al*., 2015 and Ajok, 2016).

Table 2b: Performance analysis of the cassava processors

Cost items	Amount (₦)	Percentage
Variable costs		
Roots (₦)	209910.5	59
Bags (₦)	6036.67	2
Labour (₦)	58120	16
Firewood (₦)	42226	12
Transportation (₦)	35595.83	10
Total variable cost (TVC)	351,889	99
Depreciation (₦) **(TFC)**	2973.33	1
Total cost, TC = TVC+TFC	**354,862.33**	
Quantity sold (kg) (Q)	18308.5	
Average price/kg (₦)	50	
Total Revenue, TR = (Q*P)	915,425	
Profit (TR – TC)	**560,562.67**	

Source: Field survey, 2020

CONCLUSION

The study concluded that the majority of the cassava producers were males while the remaining were females indicating that males slightly dominate cassava production in the study area. The cost and returns result shows that variable costs accounted for a very large proportion 96% of the total cost of cassava production and 99% for cassava processors. The study therefore, recommends that farmers especially women should be encouraged to grow and process cassava to improve on their livelihood and standard of living as their incomes would have increased. They should also be encouraged to form more cooperatives in order to enjoy credit facilities, increase their performance in cassava production and make high profit in the cassava business.

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ASSESSMENT OF EFFICACY OF PLANT EXTRACT ON POST-HARVEST SPECIES COMPOSITION OF TOMATO FRUIT

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ABSTRACT
Microbial infection of fruits and vegetables has been shown to impact on economic loss of perishable food crop. Tomato is an important part of a balanced diet. However they are prone to microbial attack responsible for their spoilage. Microbial species on tomato fruit samples obtained from Towobowo market was examined. Standard method of microbial analysis was used to analyze the sample for the presence of bacterial and fungal pathogens. The microbial analysis showed that Pseudomonas fluorescence, Aspergillus flavus and Geotrichum candidum species are associated with spoilage of sampled tomatoes. Inhibitory effect of the aqueous nem leaf extracts (4.0mg/ml, 6.0mg/ml, 8.0mg/ml and 10mg/ml) was observed. The efficacy test revealed that all the isolated pathogens showed maximum and minimum inhibition at 10mg/ml and 4.0mg/ml, respectively. This study confirms that, neem leaves extracts have inhibitory effect on isolated pathogens and has the potential of controlling spoilage causing agents.
Keywords: *Tomato, Microbes, Neem leaf, Concentration, Inhibition*

INTRODUCTION
The existence of microbes in plants and its economic impact did not start today and it poses challenges to post-harvest management in terms of direct and indirect loses in vegetable crops. Tomato is a fruit-bearing vegetable rich in vitamins and minerals that work as medicine in the body for healthy living. However, despite the various benefits of tomato to the body system, their contamination with microbial species could deteriorate their consumption which poses a serious menace to post-harvest management in less developed countries. Absence of appropriate post-harvest storage facilities in underdeveloped countries has contributed immensely to losses of fresh fruit and vegetables. A major challenge of post-harvest storage is diseases facilitated by high temperature and humidity. Tomatoes are identified as perishable farm commodity frequently attacked by field pathogens and surface contaminants. Post-harvest diseases such as dry rot, sour rot, green mold, rhizopus rot, soft rot are among the most important diseases affecting farm produce in developing countries and these are caused by pathogens such as *Fusarium* spp, *Geotrichum candidum, Penicillium digitatum* , *Rhizopus stolonifer* and *Pseudomonas*, respectively. Tremendous microbial post-harvest loss of fruit crops in Nigeria has been reported (Wokoma, 2008; Eni *et al*., 2010) to be between the range of 50 to 90%. They cause economic losses to farmers and sellers of such perishable produce and also health problems for the consumers. The exact negative impact of pathogens on harvested perishable crops includes suppression of their essential dietary nutrients.
Fresh fruits and vegetables sold in different markets are usually obtained from a common source and are predisposed to contamination as a result of poor cultural practices during cultivation by the farmers and after harvesting and poor hygiene level of the handler there by creating avenue for microbial contamination. In the open markets of developing countries, tomato fruits are often displayed in baskets and on benches for the prospective customers, thereby exposing them to opportunistic microbial infections especially mycotoxins (Baiyewu *et al*., 2007). These microbe producing toxins are capable of causing fungal diseases in crop and death for consumers (humans and animals).
Despite the fact that post harvest microbial deterioration of perishable crops is common in Nigeria, there is need to study their diversity in tomato fruits sourced from local markets and retailers. This study examined the post-

harvest species composition of tomato fruit sold in Igboora town, Oyo state in order to create public health awareness and provide useful data to guide in developing management in the study area.

MATERIALS AND METHODS

Collection of sample

Samples of tomato fruits used for this study were purchased from a popular Towobowo market located in Igboora, the headquarter of Ibarapa Central Local Government Area of Oyo State and the traders are made up of peasant farmers, middlemen and retailers from neighboring town and communities. The samples were collected and carried in separate sterile bags with distinct identification tag. The samples were transported to the Biology Laboratory of Oyo State College of Agriculture and Technology for microbial analysis.

Preparation of plant extract

One hundred grams (100g) of leaves (*Azadirachta indica*) at room temperature were powdered with mechanical grinder, macerated in 400ml of ethanol to soak the powdery leaves. The ethanol extraction was carried out according to the method described by Bimakr (2010) with slight modification.

Laboratory preparation of sample

A portion (100g) of each tomato was soaked in 10% normal saline for 24 hours to detach the microbial contaminants of tomato fruit. The solutions were serially diluted. A serial dilution of 1:10 from various dilution were spread out in duplicates on already prepared and solidified Nutrient agar and Sabouraud dextrose agar. Plate count was done on the media incubated at 37^{o}c for 24hours and 28-30^{o}c for 3-5days for bacterial and fungal isolates respectively.

Efficacy concentration tests

To determine the inhibitory effect of the plant extract on microbial infestation of tomato, a 0.1g of the extract was dissolved in distilled water to yield concentration of 10mg/ml, 8mg/ml, 6mg/ml and 4mg/ml. Each of these concentrations was tested against the isolates using agar well diffusion method as described by Babayi *et al*. (2007).

RESULT AND DISCUSSION

Infestation of fruit and vegetable with economic important species of microorganisms causing post-harvest spoilage has become a very important aspect in post-harvest management of perishable food crop. The microbial analysis in this study showed that bacterial and fungal species are associated with the spoilage of selected tomato fruit and this could be attributed to the infestation of the tomato during storage or at the point of purchase from the handlers. Table 1 gives the result of species composition of tomato fruit inducing spoilage microbes. The general observation of the result revealed that 2(66.7%) of the species isolated (*Aspergillus flavus* and *Geotrichum candidum)* were fungi.

Table 1. Species composition of tomato fruit inducing spoilage microbes in the study area

Pathogen	***Pseudomonas fluorescence***	***Aspergillus flavus***	***Geotrichum candidium***
Bacteria	2	-	-
Fungi	-	4	3

This observation corroborates the work of Ibrahim *et al*. (2011), Matthew (2011) and Wogu and Ofuase (2014) which showed that fungal species were more associated to tomato fruit spoilage than bacteria. Similar results was reported by Bello *et al*. (2016). It is important to note that *Aspergillus flavus* are agricultural soil fungus and opportunistic pathogens on crop which produces aflatoxins on infected crop which is harmful to human health. A non-pathogenic saprophytes bacteria isolate, *Pseudomonas fluorescence* is a useful tool in the biocontrol of pathogen causing post-harvest spoilage in crops. Such was reported by Girija and Manoj (2005). Fungal pathogens, *G. candidum*, a common soil borne fungus causing sour rot of tomato fruit is a wound pathogen that get easy chance to enter injured portion of the fruit. Table 2 shows that neem leaves extracts have inhibitory effect on post harvest pathogens. This may not be unconnected with a large number of bioactive constituents in neem.

Table 2. Efficacy of neem leaf aqueous extract at different concentration after 24 hours incubation

Concentration (mg/ml)	**Inhibition (mm)**		
	Pseudomonas fluorescens	***Aspergillus flavus***	***Geotrichum candidium***
40	23.0	24.0	23.5
60	31.5	29.5	25.5
80	32.1	34.5	32.5
100	43.5	36.5	38.3

Previous works have shown that a variety of natural plant extracts play an essential role in reducing the severity of plant diseases by acting either directly or indirectly to inhibit the growth and reproduction of fungal pathogens

(Zaker, 2016; Borges *et al*., 2018; Draz *et al*., 2019; Hassan *et al*., 2021). Another report indicates that plant extracts are effective against other plant pathogens (Elsharkawy and El-sawy, 2015). In this study, the efficacy of neem leaves extract tested at different concentration against identified post-harvest tomato isolates present differences in their inhibitory effect at common aqueous extract concentration of 10mg/ml and 4.0mg/ml on the pathogens. This may be as a result of active phytochemicals in the plant capable of suppressing spoilage causing microbes.

CONCLUSION

The outcome of this study implicated tomato fruits as carrier of species causing post harvest deterioration and the leaves of neem have the capacity to inhibit their growth.

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ENHANCING FOOD SECURITY IN SUB-SAHARAN AFRICA THROUGH POST-HARVEST MANAGEMENT

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ABSTRACT
This paper explores the crucial issue of post-harvest losses in the context of developing tropical nations, focusing on Nigeria as a case study. The study highlights the substantial losses that occur across various stages of the post-harvest chain, including harvesting, handling, storage, processing, transportation, and marketing. The impact of these losses on agricultural produce availability is particularly significant for perishable and arable crops like cassava, yam, and sweet potatoes. Estimates suggest that post-harvest losses in Nigeria can range from 35 to 45% of annual production for arable crops, fruits, and vegetables. The implications of these losses for food security are underscored, especially given the challenges faced by individuals in low-income developing countries. To address these issues, the paper emphasizes the urgent need for solutions that minimize post-harvest losses. This is vital for enhancing farmers' profits and ensuring a consistent year-round supply of essential food items. The recommendation put forth is for governments to play a role in facilitating private sector investment in food processing industries, particularly focusing on fruits and vegetables. Such investments can help curb post-harvest losses, foster economic growth, and ultimately strengthen food security. Overall, the paper highlights the importance of mitigating post-harvest losses as a fundamental step toward achieving food security in developing nations.
Keywords: *food supply chain, food waste, pre-harvest losses, post-harvest losses*

INTRODUCTION
While the current administration in Nigeria and some parts of Africa has shown strong support for agricultural development, it's noteworthy that only a mere 5% of investments in agricultural research in the past three decades have been directed toward addressing post-harvest losses (Kader and Roller, 2004; Kader, 2005). This apparent neglect can be attributed largely to a lack of awareness among various stakeholders in the food supply chain. Both buyers and farmers tend to view these losses as an inevitable cost of doing business without fully comprehending the extent of the problem. However, there is a growing realization in the food security community that these losses not only have significant economic repercussions but also jeopardize the long-term sustainability of value chains. According to FAO (2011), the pattern of post-harvest losses in agricultural products differs significantly between developing and developed nations. Developed countries experience fewer losses at the field level compared to developing nations and industrialized Asian countries. However, at the consumption level, developed nations waste a much larger portion of food (22%) compared to developing nations (<5%). In developing countries, pre-harvest losses are primarily due to substantial yield and livestock losses resulting from inadequate resilience and control over natural threats, such as biotic and abiotic stresses, which are characterized by fundamental agricultural inefficiencies and technological limitations. Post-harvest losses in developing countries are substantial due to insufficient storage facilities and frequent infestations by rodents, pests, and diseases. The availability of dry and cold storage facilities provides farmers and growers with increased market flexibility, such as not having to sell their produce immediately after harvesting, and offers economic benefits by reducing losses and enhancing overall produce quality.
The distribution of losses and waste along the food chain varies widely depending on the products and regions. In industrialized regions, significant losses occur early in the food supply chains. Technical, legal, fiscal, and organizational barriers in industrialized countries often hinder more efficient food utilization. For instance, stringent hygiene regulations within European regulations contribute to food waste in the catering industry due to overly cautious safety margins applied by companies (Waarst *et al*., 2011). In medium- and high-income

countries, food waste is prevalent at the consumption stage, where food is discarded even if it remains suitable for human consumption, particularly after cooking or on the plate.

Moreover, considering the limited availability of the world's natural resources, such as soil, water, fossil energy, and nutrients, there is a pressing need for more efficient and responsible resource utilization. In low-income countries, financial management and technical limitations in harvesting, storage, and processing techniques are often responsible for food losses and waste. Economically, these losses directly and negatively impact the incomes of both farmers and consumers. Food security remains a significant concern in much of the developing world, and while efforts to increase agricultural productivity are ongoing in Nigeria, it is evident that the solution extends beyond mere production expansion. Improving farm management practices to reduce post-harvest losses can significantly increase the available food supply by millions of tonnes annually, without the additional demands on labor, land, materials, resources, and biofuel expansion that increased production would entail.

Volume of post-harvest losses of roots and tubers

Globally, an alarming one-third of the food produced today is lost, wasted, or discarded due to inefficiencies in the human-managed food chain, amounting to approximately 1.3 billion tons annually (FAO, 2011). Additionally, studies by Tawose (2008) and Lundqvist *et al*. (2008) have suggested that 30 to 40% of the world's food crops go unconsumed due to various factors like damage, rotting, and pests and diseases that affect crops after harvesting. In Nigeria, the situation is dire, with an estimated excess of over 10 million tons of food grains lost annually due to spoilage and wastage, largely attributed to inadequate post-harvest management (FAO, 2011). Likewise, a study by FAO (2011) focused on animal production and post-harvest losses of roots and tubers in Nigeria, estimating an annual loss of approximately 86,229 metric tons of yams. These recurring losses can discourage farmers and undermine their efforts in food production, ultimately resulting in food shortages and contributing to malnutrition (Hodges *et al*., 2011; Bridget, 2013). Post-harvest losses of roots and tubers are particularly prevalent during small-scale root crop processing. This includes estimated losses during activities such as washing (0-5%), sorting (5-50%), slicing/dicing (5-10%), packaging (0-10%), and rejection (0-5%). Losses of 28% for cassava and 37% for yam, primarily due to damage during harvest have also been reported.

New challenges and strategies in addressing post-harvest losses

Challenges in reducing post harvest loss

Addressing post-harvest losses in developing countries like Nigeria presents a complex challenges, with various interconnected factors contributing to the problem. Key drivers of food loss include the absence of extension services to educate farmers on proper handling, packaging, and storage practices; inadequate post-harvest storage facilities and technologies, and limited market access. Past efforts have primarily focused on technology-based solutions, such as on-farm storage using hermetically sealed bags, solar-powered refrigeration for fruits and vegetables, and mobile grain drying systems. However, more recent approaches have shifted towards a broader market-based strategy to enhance the overall efficiency of the value chain.

Despite these efforts, several emerging issues and obstacles continue to impede progress in reducing food loss and these includes:

i. Insufficient awareness and knowledge about the causes of post-harvest loss and effective prevention techniques.
ii. Disrupted distribution channels for technologies aimed at reducing food loss.
iii. Limited technical expertise among smallholder farmers.
iv. Inadequate access to credit and financing for implementing loss-reducing measures.

To effectively address post-harvest losses and work towards achieving Sustainable Development Goals (SDGs) in Nigeria, there is a need for capacity development. It has been shown that approximately one-third of the country's food production never reaches its intended consumers. To combat this issue comprehensively, it is crucial to not only introduce appropriate technologies but also provide education, training, and support to farmers. While technology improvements are essential, they should not hinder immediate actions that can benefit smallholder farmers and society as a whole. Suitable technologies already exist, and their adoption by farmers can significantly reduce post-harvest losses.

Therefore, a vital aspect of reducing food losses involves educating farmers on improving post-harvest management. Drawing from successful practices implemented by organizations like the WFP in Uganda and Burkina Faso from 2012 to 2014; capacity development and skills training should focus on increasing farmers' awareness of critical biological and environmental factors throughout key stages of harvesting, drying and solarization, threshing, and on-farm storage. Furthermore, efforts should be made to facilitate government and financing agencies' on lending programs, promoting aggregation, appropriate packaging and storage, and facilitating connections with buyers. These initiatives can help alleviate some of the challenges associated with post-harvest losses.

Enhancing food security and economic empowerment

To effectively mitigate post-harvest losses and food wastage, a multifaceted approach is necessary. This approach should encompass raising consumer awareness, altering consumption habits, and reshaping incentives within the private sector's supply chain participants. It's important to recognize that strategies for reducing waste and losses will vary between developed and developing nations due to distinct root causes. Nevertheless, addressing waste and losses in both contexts is crucial for combating hunger and enhancing nutritional security in developing countries while meeting the growing global food demand.

To achieve sustainable food security goals, it's imperative to enhance food availability by minimizing post-harvest losses at various levels, including farms, retail, and among consumers. This involves maintaining adequate infrastructure, expanding cold storage facilities, and effectively disseminating technologies and market information. Striving for a "zero wastage" status in agricultural produce is a key step towards realizing a "Hunger-free Nigeria" and requires dedicated efforts.

Reducing post-harvest losses in developing countries necessitates investments from both the public and private sectors in agricultural research, development, and extension services. This includes allocating resources to suitable storage technologies and enhancing infrastructure to improve the connectivity of smallholder farmers with local, regional, and international markets. Conducting cost-benefit analyses to determine the returns on investment in recommended post-harvest technologies is essential, enabling the selection of technologies appropriate for various post-harvest enterprises across different farmers.

Urgent action is required to establish additional cold storage facilities in various regions for different types of commodities. Governments in affected countries should prioritize foreign direct investment (FDI) and capital injection into this endeavor. Raising awareness about available facilities within the country to reduce post-harvest losses is also crucial. Implementing market innovations and reforms is indispensable for advancing the campaign to reduce food waste.

CONCLUSION AND RECOMMENDATIONS

Given the challenging living conditions faced by many individuals in developing nations like Nigeria, it is of utmost importance to urgently seek solutions to mitigate post-harvest losses. Such efforts can enable farmers to maximize their income and ensure a consistent supply of food, fruits, and vegetables throughout the year. As a recommendation, governments should actively facilitate the development of infrastructure that encourages private sector investments in the food processing industry, particularly for fruits and vegetables. This measure holds significant potential for reducing post-harvest losses, promoting economic growth, and strengthening food security.

Furthermore, it is essential to emphasize the need for practical policies and steadfast leadership to address this issue effectively. To achieve future food security goals, it is crucial to ensure a substantial reduction in post-harvest losses. This requires a collective effort from all sectors of society, including the public sector, private sector, and civil society. Everyone should recognize the pivotal role they can play in establishing and maintaining a robust support system that facilitates decision-making and the adoption of technologies aimed at reducing post-harvest losses in Nigeria.

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APPRAISING THE NUTRITIONAL COST OF *SITOPHILUS ZEAMAIS* MOTS. INFESTATION AND STORAGE IN MAIZE (*ZEA MAYS* L.) GRAINS

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ABSTRACT

Cereal grains (maize/corn; Zea mays L. inclusive) are generally the major and least expensive sources of carbohydrate, protein, certain minerals and vitamins in the developing countries. Insect infestation however, has been shown to cause significant quantitative and qualitative damage of stored products. However, due to a dearth of information on the effect of infestation and storage on the nutritional content of maize grains in particular, an investigation into appraising nutritional cost vis-a-viz infestation was carried out. 4 kg of pest free orange coloured maize variety (SAMMAZ 49) and sorted into 2 groups: STM_{01} and STM_{02} and infested with unsexed Sitophilus zeamais Mots. Both samples were stored under ambient laboratory conditions for 3 months after which they were processed and alongside with freshly harvested, uninfested processed samples (FRM_{01}). Significantly ($p<0.05$) higher amount of zinc, copper, sodium, potassium and magnesium was observed in the infested + stored grains (STM_{01}) over and above the uninfested + stored grains (STM_{02}) and freshly harvested + uninfested grains (FRM_{01}) by 10.5 to 97.5%. Vitamin C was at levels below detection in all the samples; while FRM_{01} and STM_{02} had 0.12±0.00 mg/100g and 0.10±0.02 mg/100g Vitamin A content, respectively. STM_{01} had undetectable quantity of Vitamin A. Furthermore, infestation and storage was observed to suppress protein, carbohydrates and dietary fiber content by 24.7 to 77.8%; while a 30.2% increase in moisture content was attributable to S. zeamais infestation + 3 months storage of the grains. Further study is recommended to aid modelling the relationship between infestation and storage vis-a-viz nutritional status of the grains.

Keyword: *Infestation, Pest, Sitophilus zeamais Mots., Stored, Zea mays L.*

INTRODUCTION

Maize or corn (*Zea mays* L.) is a major cereal crop with rising global increase in demand. Having a predicted global increase of ≈ 370 metric tons by 2023 from the initial 967 million metric tons, maize is estimated to account for the greatest share (34%) of the total harvested crop area globally, making maize of inestimable value with regards to global food security (Rouf Shah *et al.*, 2016; Samuel *et al.*, 2021; Medugu *et al*., 2023). Africa produces roughly 7% of global maize production with constant increase in total cultivated land area. The role of maize in the sub-region is enormous as the crop has successfully substituted other staple crops such as sorghum and millet in terms of quantity consumed per household as well as becoming a major source of income for smallholder farmers (Medugu *et al*., 2020; Samuel *et al.*, 2021).

Although, majorly considered as a carbohydrate rich crop, the nutritional composition of maize kernel has generally been reported to consist of important vitamins such as vitamin C, vitamin E, vitamin K, vitamin B_1 (thiamine), vitamin B_2 (niacin), vitamin B_3 (riboflavin), vitamin B_5 (pantothenic acid), vitamin B_6 (pyridoxine), folic acid, selenium, N-p-coumaryl tryptamine, and N-ferrulyl tryptamine (Rouf Shah *et al.*, 2016). Major minerals like Potassium which has a good significance in the human diet as well as about 45–50% of oil that is used in cooking and making of salads is obtained from wet milling process of maize kernel (Kumar *et al.,* 2013; Rouf Shah *et al.,* 2016). These among others is instrumental in maize been referred to as "a life giver" (Kumar *et al.,* 2013).

Considering the global importance of maize and despite high estimation of global production of the crop, attention is drawn towards factors which affect its production vis-a-viz its nutritional composition as there exists evidence of seed and food insecurity arising from storage losses of the crop majorly due to the problem of insect pests. Maize weevil (*Sitophilus zeamais*) and its relatives such as rice weevil (*S. oryzae*), Angoumois grain moth (*Sitotroga cerealella*) and the larger grain borer (*Prostephanus truncatus*) represents the major pre-harvest and post-harvest pests of maize, causing up to 40% losses during cultivation and a whopping 90% postharvest losses (Tefera *et al.,* 2011; Rouf Shah *et al.,* 2016; Medugu *et al*., 2023).

Maize weevil is a primary storage pest which infests intact kernels. Through the feeding activities of adults and the development of immature stages, the insect is able to create holes in whole and undamaged grains, reducing them to powder and causing the grain to lose sufficient nutrient, viability and market value (López-Castillo *et al.,* 2018). The pest has cosmopolitan distribution as it is found in numerous warm and humid regions worldwide (López-Castillo *et al.,* 2018). Of concern is that, among factors that affects productivity and nutrient composition of maize such as geographic location, soil nutrient and others, the effect of insects such as *S. zeamais* have played a more significant role in deterring the productivity as well as the nutrient content of the crop (Rouf Shah *et al.,* 2016; Medugu *et al*., 2020; Samuel *et al.,* 2021).

Wukari is a high maize producing community which is also threatened by *S. zeamais* infestation. The high cost of chemical pesticides used in storage of the crop has also resulted in the high market price of the grain, leaving majority of the poor masses with the only option of purchasing insect infested grains for consumption due to their relatively low prices. In a bid to attract better market price, the crop is stored for a longer time by the growers. Inadequate knowledge of the nutritional value of these consumed damaged and long stored grains exists. Hence while the poor masses are threatened with malnutrition by consistent consumption of damaged maize grains, the bourgeoisies may equally be threatened by same via consistent consumption of "over stored maize grains". Hence this study is designed to determine the effect of storage period and *S. zeamais* infestation on the nutritional characteristics of maize grains.

MATERIALS AND METHODS

Source of raw materials

Four (4) kilograms of pest free orange colored maize variety (SAMMAZ 49) was bought from a registered agrochemical dealer in Wukari and transported to the Biological Science Laboratory of Federal University Wukari for further processing.

Sample preparation

The grains were carefully sorted to ensure that only uninfested ones were used for the study. The sorted grains were divided into 2 main groups and kept in different plastic containers labelled STM_{01} and STM_{02} and covered with a mesh size that would only permit aeration. Forty (40) adult unsexed *S. zeamais* were manually introduced to samples STM_{01} while sample STM_{02} was uninfested. The samples (STM_{01} and STM_{02}) were stored in laboratory condition for 3 months, after which each sample was washed using clean water, air-dried, and milled in an attrition mill and sieved using a mesh with size screen (0.01mm). Fresh maize grain (1kg) labelled FRM_{01} was harvested from the field and processed into flour using the same method outlined for STM_{01} and STM_{02}. This was used as the control. 500g of each flour sample was packaged in high density polyethylene bag, well labelled and stored at (4±2^{o}C) in a refrigerator prior to laboratory analyses (Dereje and Solomon, 2020).

Analytical methods

All samples were safely transported to the Central Laboratory of Federal University Wukari for analysis using standard procedures as described below:

Determination of mineral content

One gram of each maize flour sample was used for analysis of mineral content (zinc, copper, sodium and potassium) present in the samples, following the atomic absorption spectrophotometric method described by Howe *et al.* (2005) where a gram of each samples was accurately weighed and put into 250 ml graduated beakers and labelled. A 3:1 mixture of nitric and hydrochloric acids (20 ml) was added to each beaker, covered with a polyethylene watch glass and allowed to stand overnight. The next day the mixture was digested for 2 hours at 115 ^{o}C. After cooling to room temperature, the digestate was made up to 50 ml. The resulting solutions were analyzed by Flame (for Zn, Cu, Na and K) using a Perkin Elmer 5100PC spectrometer.

Determination of vitamin content

Vitamin content in each sample was determined by High Performance Liquid Chromatography as described by George *et al.* (2015). 2 g sample of each substrate was weighed into separate 50 ml polypropylene tubes and 30 ml of 3% metaphosphoric acid was added and homogenized using a homogenizer. The mixtures were sonicated in ultrasonic bath for 5 minutes, vortexed and centrifuged at 845×*g* for 5 minutes. The supernatants were filtered using 0.25 μm membrane for HPLC analysis. Sample separation was achieved using an Ultra-Performance Liquid Chromatography system. Chromatographic separation was performed on a UPLC system equipped with an auto-sampler column oven, pumps and Prominence Diode Array Detector. The mobile phase composition consisted 0.3 mM potassium dihydrogen phosphate in 0.35% (v/v) phosphoric acid at a flow rate of 0.2 mL/min at ambient temperature. Injections of 20 μL was performed with a total run time of 12 min. Data were extracted at a wavelength of 242 nm while compound identification was based on matching of the retention times with pure ascorbic acid and vitamin A.

Proximate analysis

Determination of moisture content

The moisture content of samples were determined using the procedure described by AOAC (2010). Five grams of the samples was weighed into different aluminium moisture cans. The samples were then dried to constant weight at 105±2ºC and the moisture content was calculated as:

$$\% \, Moisture\ content = (weight\ of\ can + sample) - (weight\ of\ empty\ can) x\ 100/weight\ of\ sample$$

Determination of protein content

The macro Kjeldhal method as described by the AOAC (2010) method was used. Ten grams of the samples were weighed into different conical flasks (250 m1), 0.8 g of the catalyst (potassium sulphate) was poured into each of the conical flask and 5m1 of sulphuric acid and three glass beads (anti bumps) were dropped inside the conical flask and swirled. The mixture was heated on the Kjeldhal apparatus for 2-3 hours at 100°C, until it turned bluish white. The digest was allowed to air cool, then diluted with 10 ml distilled water. These were distilled using Markham distillation apparatus where l00 m1 conical flask containing 5 ml of boric and 2-3 drops of mixed indicator was attached. The 5 ml of the digest was introduced into the body of the apparatus and followed by l0 m1 of 40-45% sodium hydroxide solution. The distillate was collected as ammonium sulphate which was titrated against 0.1 M hydrochloric acid. A blank titration will be carried out using distilled water instead of the distillates. Percentage nitrogen was calculated using the formula:

$$\% \, Nitrogen = Titre\ value - \ blank\ x\ 0.0014g\ x\ 100\ x\ 25/weight\ of\ sample\ x\ 5\ ml$$

$$\% \, Crude\ protein = \% \, N\ x\ \ 6.25\ (conversion\ factor)$$

Determination of ash content

The ash contents were determined by the AOAC (2010) method. Two grams each of the samples was weighed into a dried pre-weighed porcelain crucible. Each sample was transferred into a preheated muffle furnace (carbolite Bamford S30 2AU) and heated at 550°C for 2 hours. The ash was removed, cooled in a desiccator and weighed, while the percentage ash content was calculated as:

$$\% \, Ash = Weight\ of\ ash\ x\ 100/Weight\ of\ sample$$

Determination of fiber content

Crude fiber of the samples was determined using the method described by the AOAC (2010) method. 2g sample was weighted into 500 m1 beaker and in 200 m1 boiling sulphuric acid for 1 hour 30 minutes. The suspension was filtered using a white filter paper and rinsed with hot water to obtain the filtrates. The residue obtained was transferred into a crucible and placed in an oven for 30 minutes. The dried residue was cooled in a desiccator and weighed. Percentage crude fiber was calculated using the formula:

$$\% \, Crude\ fiber = Loss\ in\ weight\ after\ incineration\ x\ 100/Weight\ of\ sample$$

Determination of carbohydrate content

Carbohydrate was calculated by difference as described by Ihekoronye and Ngoddy (1985).

$$\% \, Carbohydrate = 100 - (\% \, Moisture + \% \, Fat + \% \, Protein + \% \, Ash + \% \, Crude\ fibre)$$

Statistical analysis

The experiment was carried out on completely randomized design (CRD). The data were analyzed by one way analysis of variance using Statistical Package for Social Sciences (SPSS) software version 20. Means that were significantly different, were separated by the Least Significant Difference (LSD) test. Significance was accepted at $p < 0.05$.

RESULTS AND DISCUSSION

After 3 months of storage, results as shown in Table 1 revealed that infested + stored grains (STM_{01}) had significantly ($p < 0.05$) higher amount of zinc, copper, potassium, and magnesium than the other 2 treatments by an average of 10.5 to 97.5%. The result further showed that, differences in zinc, copper and magnesium content between uninfested + stored (STM_{02}) and freshly harvested + uninfested (FRM_{01}) were due to random variation ($p > 0.05$). However, while sodium content in STM_{02} (16.30±0.40 mg) was significantly ($p < 0.05$) higher than that in FRM_{01} (15.17±0.30 mg); the reverse was the case with respect to potassium with 0.13±0.00 mg and 0.40±0.00 mg values, respectively.

The analyses of Vitamin A and C carried out on the samples showed that Vitamin A was insignificantly ($p > 0.05$) higher in freshly harvested + uninfested maize grains (FRM_{01}) with a concentration of 0.12±0.00 mg/100g vis-a-viz uninfested + stored grains (STM_{02}) which had (0.10±0.20 mg/100g). The insect infested and stored grains (STM_{01}) had an undetected amount of Vitamins A and C across all the samples (Table 2).

Table 3 shows that infestation + storage significantly ($p < 0.05$) depletes protein, carbohydrate and fibre content of the maize grains by an average of 77.8, 72.3 and 24.7%, respectively. On the other hand, infestation was noted to significantly ($p < 0.05$) favour moisture rise by up to 30.2%.

Table 1. Mineral content of stored infested, stored uninfested and fresh uninfested maize grains

Mineral content (mg)	STM_{01}	STM_{02}	FRM_{01}
Zinc	$0.25^{a}\pm0.01$	$0.15^{b}\pm0.00$	$0.10^{b}\pm0.35$
Copper	$0.27^{a}\pm0.30$	$0.02^{b}\pm0.20$	$0.05^{b}\pm0.25$
Sodium	$17.58^{a}\pm0.00$	$16.30^{b}\pm0.40$	$15.17^{c}\pm0.30$
Potassium	$0.72^{a}\pm0.20$	$0.13^{c}\pm0.00$	$0.40^{b}\pm0.00$
Magnesium	$0.80^{a}\pm0.12$	$0.02^{b}\pm0.00$	$0.02^{b}\pm0.00$

Means bearing different superscript on the same row differ significantly at ($p < 0.05$)

Table 2. Vitamins A and C content of stored infested, stored uninfested and fresh uninfested maize grains

Vitamin content (mg/100g)	STM_{01}	STM_{02}	FRM_{01}
Vitamin A	$0.00^{b}\pm0.00$	$0.10^{a}\pm0.02$	$0.12^{a}\pm0.00$
Vitamin C	ND	ND	ND

Means bearing different superscript on the same row differ significantly at ($p < 0.05$)
ND: Not detected

Table 3. Proximate composition of stored infested, stored uninfested and fresh uninfested maize grains

Proximate (g)	STM_{01}	STM_{02}	FRM_{01}
Protein	$0.10^{c}\pm0.20$	$3.47^{b}\pm3.55$	$8.07^{a}\pm3.77$
Carbohydrate	$10.04^{c}\pm0.22$	$24.60^{b}\pm2.55$	$71.10^{a}\pm2.46$
Ash	$1.28^{b}\pm0.82$	$2.30^{a}\pm0.30$	$1.17^{c}\pm1.01$
Moisture	$12.50^{a}\pm0.3$	$7.37^{c}\pm3.47$	$10.08^{b}\pm0.94$
Fiber	$0.90^{b}\pm0.94$	$1.30^{a}\pm1.01$	$2.92^{a}\pm0.09$

Means bearing different superscript on the same row differ significantly at ($p < 0.05$).

Factors such as storage condition and duration, as well as pest infestation among others have been reported to greatly influence the nutritional composition of maize (Tefera *et al.*, 2011; Rouf Shah *et al.*, 2016; Stathas *et al.*, 2023). In this study, value of the mineral content obtained from FRM_{01} samples largely agreed with the reports of Rouf Shah *et al.* (2015) for freshly harvested maize samples. However, the comparative higher values of the minerals (Zinc, Sodium, Copper, Potassium and Magnesium) as observed in STM_{01} sample can only be attributed to the combined effect of both storage duration and insect infestation. Insect infestation has been shown to increase mineral content as indicated by the study of Jood and Kapoor (1994) in their research with *Trogoderma granarium* and *Rhyzopertha dominica*. Although intake of these minerals is of immense health benefits (Rouf Shah *et al.*, 2016), excessive consumption of Zinc and Magnesium has been reported to be associated with health problems such nausea, headache, vomiting and stomach upset (Rouf Shah *et al.*, 2016).

Of interest is the undetectable level of Vitamin A level in STM_{01} sample as against what was obtained in STM_{02} and FRM_{01}. This largely suggests that the activities of insect infestation on maize grains, suppress Vitamin A content. Further, the undetectable level of Vitamin C in all the samples analyzed showcased the deficiency of the grains in Vitamin C. This buttresses the findings of Garg *et al.* (2021) and Galani *et al.* (2022) who reported that maize grains have insignificant quantity of Vitamin C.

Proximate properties of the maize samples used in this study had similar results in FRM_{01} values for Protein, Carbohydrate, Moisture, Ash and Fiber reported by Rouf Shah *et al.* (2015). However, the significant lower nutrient value of protein, carbohydrate and fiber in STM_{01} sample vis-a-viz the other samples may be attributed to the combined effect of storage and *S. zeamais* infestation, and this buttresses the finding of Tefera *et al.* (2011) which showed that insect infestation reduces nutrient quality of maize. A study conducted by Ojimelukwe *et al.* (1999) showed a 19 – 28% decrease in protein content of cowpea as a result of insect infestation. They attributed the depletion to the utilization of the protein nutrient by the insect pest. Our findings however showed a far greater (≈ 77.8%) reduction attributed to infestation and storage. This apparently shows the extent infestation and storage could deplete proteins in grains. In contrast however, Jood *et al*. (1993) observed a 75% increase in mean protein content in infested cowpea which was suspected to be due to the presence insect excrements and body fragments. Approximately, we noticed 77.8 and 77.2% increase in protein and carbohydrate content in the infested and stored maize samples. This was in contrast with the observation of Stathers *et al*. (2020) who noticed a decrease in carbohydrate and an increase in protein content as a result of insect infestation. This difference may be due to differences in grain varieties, analytical methods or experimental procedures. The ≈ 24.7% decrease in dietary fiber in sample STM_{01} in our study could be attributed to the insect feeding on the soluble portion of the fiber. Hence, the freshly harvested maize grains (FRM_{01}) which had significantly higher fiber content could be adjudged to have better physiological and health advantages by way of lowering cholesterol level, regulating blood sugar, and prevention of diabetes and certain forms of cancer (Akah and Onyeka, 2017). High moisture content was observed in STM_{01} following the 3 months storage. This also suggests that insect infestation and activities could possibly be responsible for increase in moisture content of the maize sample as earlier reported by (Stathers *et al*., 2020).

CONCLUSION

Although storage duration also influenced the nutritional composition of the maize samples used in this study, a combined effect of insect infestation was observed to be more deleterious on the nutrient content. This suggests that consumption of insect infested maize may not only lead to malnutrition, but also contributes to some disease cases such as gastro-intestinal dysfunction, liver and heart diseases among others, due to a disproportionately higher amount of minerals. More extensive studies are thus recommended to enable modelling the association between infestation and storage on one hand against nutritional losses.

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ENHANCING FOOD SECURITY VIA IMPROVED HARVEST AND POST-HARVEST MANAGEMENT OF ROOT AND TUBER CROPS (RTCS)

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ABSTRACT
Roots and tubers play a significant role in ensuring food security, especially in developing countries where they are staple crops for millions of people. However, improper harvest and postharvest management practices often result in substantial losses, reducing food availability and contributing to food insecurity. This paper highlights the importance of enhancing food security through improved harvest and postharvest management of root and tuber crops. Improving harvest management involves implementing appropriate techniques to ensure the timely and efficient collection of roots and tubers. Traditional methods, such as hand harvesting, are often labour-intensive and time-consuming, leading to delays that can negatively impact the quality and quantity of crops. Introduction of mechanised and semi-mechanised harvesting technologies can significantly enhance efficiency, reducing losses and improving food security. Postharvest management plays a crucial role in minimizing losses and extending the shelf life of root and tuber crops. Common challenges faced during postharvest handling include physiological deterioration, sprouting, pest infestation, and improper storage conditions. Implementing improved postharvest practices, such as cooling, packaging, and the use of other appropriate storage technologies can significantly reduce losses and improve food availability. More so, enhancing food security through improved harvest and postharvest management requires the involvement and capacity building of smallholder farmers. Providing them with training, technical support, and access to improve technologies can empower them to adapt best practices and reduce losses during harvest and postharvest stages. Overall, enhancing food security via improved harvest and postharvest management of root and tuber crops is crucial for reducing food losses, increasing availability, and ensuring a stable food supply. By addressing the challenges associated with these key stages, policymakers, researchers, and farmers can work together to achieve sustainable food security for the growing global population, particularly in vulnerable regions that are highly dependent on roots and tubers.
***Keywords:** Root and Tuber crops; Food Security; Harvest; Post Harvest Management*

INTRODUCTION.
Roots and tuber crops, including yam (*Dioscorea* spp.), cassava (*Manihot esculenta* Cranz), potato (*Solanum* spp.), sweet potato (*Ipomoea batatas*) and edible aroids (*Colocasia* spp. and *Xanthosoma sagittifolium*) can contribute significantly to meeting the nutritional needs of vast majority of people and reducing hunger. Hence, roots and tuber crops can play crucial role in sustainable food security. These crops are the second most important food crops after cereals in many regions of the world. They are grown in varied agro-ecologies and production systems ranging from highland densely populated regions to lowland drier areas prone to droughts or floods. These crops account for about 95% of the total root and tuber crops production in Africa and produce more than 240 million tons annually on 23 million hectares (NRCRI 2008; FAO, 2009; IITA, 2015).

Root and tuber crops such as yam, cassava, cocoyam, potato and sweet potato are cheap but nutritionally rich staple foods that contribute starch or carbohydrate, protein, minerals, vitamins (like vitamin C, vitamin A etc), zinc, and iron towards the dietary demands of the region's fast-growing towns and cities. They are referred to as poor man's crops and have considerable unrealized potential for processing into high end products for food, animal feed and industrial uses (Nteranya, 2015).

Root crops such as potato and sweet potato crops have short life cropping cycle that may range from three to four months. They are suitable for double cropping seasons especially in rain-fed systems, with significant advantage over cereals which have longer time to harvest. Due to root crops short growing periods, they have flexible planting and harvesting period which may allow quick food availability to sustain hunger. Tuber crops like yam

and cassava, with long cropping cycles, are good for annual cycle of food production. They are grown in marginal environments as well as having diverse maturity period with storage capability that allows flexible planting and harvesting periods which helps to sustain food production (FAO, 2009).
The crops can be traded locally and nationally even exported internationally. As such, they significantly contribute to a more stable food system and predictable source of income. Their perishable nature, coupled with challenges in long distance conveyance, storage and marketing creates major threats for small scale farmers. Root and tuber crops are affected by many pathogenic and physiological disorders during the post harvest storage periods resulting to great economic loss. These crops are still living organisms when harvested and their losses during storage occurs mainly as a result of its physical and physiological conditions (Scott *et al.*, 2000). In order to maintain their freshness, farmers, in different parts of the world, have developed several simple, low-cost traditional methods to store these root and tuber crops. To ensure effective storage of root and tuber crops, these major causative factors need to be properly understood, and be properly controlled, taking into account the socio-economic factors which prevail in the areas of production and marketing. For most root and tuber crops, a significant proportion of the crop is processed. Transformation of the crop into a more storable form reduces physical losses as well as providing income and employment. Where processing leads to increased value of the product it can effectively change a situation of postharvest loss to one of net economic gain (Karya, 2019).
Harvest and Post Harvest Management Strategies.
1). Timely Harvesting: Proper timing of harvest is critical as it affects the quality and storage life of root and tuber crops. At their maturity time, these crops show signs and indications of their readiness for harvesting. Harvesting too early or too late can result in yield losses and reduced storability. Therefore, harvest at the right maturity stage to ensure their economic value, maximum yield and quality. Delayed harvesting can lead to spoilage, loss of nutrients, and reduced market value. Table 1 showed the harvesting period of these crops, and their harvesting period mainly depend on the type of crops, varieties and growing conditions (Krishnakumar *and* Sankarakutty, 2021).
There are commonly used criteria to ascertain the harvesting time root and tuber crops. For cassava; as soon as the foliage begins to dry, it shows that the crop is due for harvest. Same applies to sweet potato. For sweet potato however, the production of white gum but not green or black by the crop indicates readiness for harvest. Yams are harvested when their foliage begin to wilt with a corresponding enlargement of the tubers. Over maturity of yam may be tough and fibrous tubers. In Cocoyam; harvest is due when the foliage turns yellow and start to wither.

Table 1. Harvesting Period of root and tuber crops (RTCs)

Root and tuber crops	Maturity period
Cassava	6-10 months
Sweet Potato	5-6 months
Potato	3-4 months
Cocoyam	5-7 months
White Yam	9-10 months
Yam Beam	4-5 months

2. Efficient handling method: After harvest, root and tuber crops should be handled with care to prevent physical damage and bruising, which can lead to harvest losses such as rotting. Many causes of postharvest losses can be suppressed by minimizing mechanical injuries during harvest, avoiding harvesting at high temperature and preferably harvest in dry weather. The use of proper tools and techniques and carefully lifting or digging the tubers could reduce harvest losses. The use of manual means either by digging or lifting is time-consuming but it results in healthy harvest produce as compared to that from the mechanical means of harvesting. Root and tuber crops, when cultivated in commercial quantity are handled and harvested by mechanical means. However, careful handling to prevent cuts and bruises to the tubers during harvesting is critical. The crops should be harvested along with their vines or stems to slightly prolong the shelf life (Oke-Okoro *et al.*, 2014).
3. Cleaning and sorting: Clean the harvested crops to remove dirt, debris, and any damage or diseased parts. Sort them based on size, shape, and quality to ensure uniformity and marketability (Scott *et al.*, 2000).
4. Transportation of root and tuber crops: Proper transportation of root and tuber crops can preserve and maintain the quality and freshness of the produce. More than 10 to 20 % postharvest losses in fresh produce can happen due to improper transportation methods. To maintain quality and reduce loss, the crops should be packed in cartons or sacks/bags with cushioning materials like paper pieces, crop hays/straws etc. to prevent mechanical injury during transport. While transporting the crops, the produce must be protected against the sun, rain and dust by covering it with a light-coloured tarpaulin or enclosing it in a refrigerated truck. Over speeding, and unnecessary jumping into pot holes must be avoided, as they cause squeezing and bruising of the crops. Loading

and offloading of produce must be done with carefully. Packed produce must be handled gently to avoid bruises (Krishnakumar *and* Sankarakutty, 2021).

5. Pre-cooling of root and tuber crops: Pre-cooling aids to conserve the weight of the tubers and prolong the storage life. Pre-cooling could be handled either by using hydro-cooling means, air cooling or vacuum cooling method for quick removal of heat from produce. This depends on the perishability and refrigeration equipment of the produce, its adoptability to a specific method and the availability of facilities (Scott *et al.,* 2000).

6. Curing: Curing involves subjecting harvested crops to specific temperature and humidity conditions to toughen their skins and heal any minor injuries and to reduce water loss and spoilage during postharvest. Curing improves shelf life and quality, especially for crops like sweet potato, yam and cassava. Curing is an important practice for these crops. If ventilation is poor, uncured tubers may start to rot. Curing can be done in a well-ventilated shed or in the sun. Curing period depends on the type of the root and tubers and varied between four to six days. Curing operation is to be carried out as soon as possible after harvest (Krishnakumar *and* Sankarakutty, 2021). Curing periods depends on the species/variety of crops, condition of the crop at harvest, type of wound, season, storage temperature and relative humidity. The best conditions for curing vary among crops as shown in the Table 2.

Table 2. Optimal temperature and relative humidity for curing of different RTC

Root and tuber crops	Temperature($0^{o}{}_{C}$)	Relative humility (%)	Days
Cassava	30-40	90-95	2-5
Sweet potato	30-33	85-95	5-7
Yam	29-40	90-95	5-7
Cocoyam	26-330	-	7-15

7. **Improved packaging practices and marketing**: Use appropriate packaging materials that provide protection against moisture, pests and physical damage. Proper ventilation should be maintained for the packed tubers. Proper selection of packaging materials is important to increase the shelf life of the product without affecting its quality. Multi-layered packing material can be used for long term storage of flours/starch. For tuber crops, packaging materials like gunny bags, palm baskets, paper cartons, perforated plastic bags for pre-packaged tubers, solid black crates and polyethylene bags can be useful. Proper labelling and branding can also facilitate marketability, and ensure consumers are aware of the quality and nutritional value of the products. This can enhance their market value and provide economic opportunities for farmers. Develop efficient supply chains and linkages between farmers, processors, and consumers. Improve the transportation infrastructure and establish market information systems to facilitate timely and profitable sales (Magbalot-Fernandez and Umar, 2018).

8. Storage facilities: Invest in proper storage facilities such as warehouse, cold rooms, or ventilated containers to main the quality and freshness of root and tuber crops. These facilities should have controlled temperature, humidity and ventilation to prevent spoilage and pest infestation. At room temperatures, fresh produce can spoil quickly, there is need to sell them as soon as harvested. However, these crops could be stored under cold storage facilities for longer periods. Tubers are protected at safe optimal temperature from chilling injury, which cause internal browning, surface pitting and increased susceptibility to spoilage (Okunneye, 2002). Best storage practices include: Storing only sound and good quality crops: clean, mature, and disease free, injury free produce. They Should be stored immediately after harvest for better storage life. The containers and the storage rooms should be clean to prevent contamination and spoilage of fresh produce. Also, inspect the stored produce on regular basis to remove spoiled ones. Table 3 showed that there are different storage techniques which are practiced by farmers to ensure prolonged shelf life of tuber crops.

Table 3. Recommended storage conditions for shelf life extension for root and tuber crops

Root and tuber Crops (RTC)	Temp. (0^{0c})	Relative humidity (%)	Potential Storage duration
Cassava	5-8	80-90	2-4 wks
Sweet potato	12-14	85-90	6 months
Yam	13-15	95-100	6 months
Cocoyam	13-15	85-90	4 months

9. Processing and value addition of RTC: Explore processing techniques such as drying, milling, and fermentation to extend the shelf life of root and tuber crops. Processed products like flour, chips, and snacks can increase their market value and reduce postharvest losses. Root and tuber crops can be consumed after boiling the peeled and sliced tubers in water and eaten with some spicy curry. They should not be eaten in raw state as they contain anti-nutrients like cyanide in cassava, oxalates in yam and cocoyam. Their processed products are packaged and stored to achieve their potential shelf life of up to two to twelve months. Dried food products made from tuber crops must be packaged in air-tight containers. Dried products take up much less space than their fresh equivalents, further reducing transport and storage costs (Christopher, 1995).

10. Postharvest loss reduction: Addressing postharvest losses is crucial to maximize the amount of food available for consumption. Measures such as improved infrastructure, including access to efficient transportation systems and adequate storage facilities, can help reduce losses due to spoilage and damage during transportation. Implementing postharvest technologies, such as low-cost cooling systems and modified atmospheric packaging, can also prolong the shelf life of root and tuber crops (Okunneye, 2002).

11. Training and capacity building: Providing training and technical assistance to farmers on best agricultural practises in harvest and postharvest management techniques, can improve their knowledge and skills in handling root and tuber crops. Capacity building initiatives can also focus on educating farmers about market requirements, grading, quality standards and value-added processing techniques to enhance the economic value of their produce (Oke-Okoro *et al.*, 2014).

12. Research and innovations: Support research and development efforts to improve postharvest technologies, storage methods, and value addition for root and tuber crops. Encourage innovation and adoption of new technologies to enhance food security and reduce postharvest losses (Oke-Okoro *et al.*, 2014).

CONCLUSION

Enhancing food security through improved harvest and post-harvest management of root and tuber crops is crucial for communities and countries that rely on these crops as staple food sources. By implementing better practices and technologies, we can reduce post harvest losses, increase yield and quality, and ensure a stable food supply throughout the year. Improvements in harvest and post-harvest management can include the use of appropriate machinery and tools, such as mechanical harvesters and storage facilities, to minimize damage and losses. Training and education for farmers on proper harvesting techniques, cleaning, grading, and storage methods can also greatly contribute to reducing losses and maintaining crop quality. Again, investing in research and development for better varieties of root and tuber crops that have higher yield potential, resistance to diseases and pests, and improved storage life can further enhance food security. Promoting sustainable farming practices such as the use of organic fertilizers and integrated pest management, can protect crops from post-harvest losses, increase productivity, and ensure a steady supply of nutritious food for all.

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ASSESSMENT OF POSTHARVEST HANDLING PRACTICES OF GREEN LEAFY VEGETABLES AND ITS CHALLENGES AMONG HOLDERS IN ILORIN, NIGERIA

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ABSTRACT
Marketing and distribution of leafy vegetables is very crucial for sustainability of the whole value chain. This study was conducted to evaluate the postharvest handling practices of vegetable handlers in Ilorin and environs in order to assess their level of awareness of Nigerian Stored Products Research Institute (NSPRI) developed technologies for green leafy vegetables and their challenges. A total of 30 respondents were purposely selected from five locations (150 respondents). Structured questionnaires were administered to respondents for data collection and their responses were analysed through the use of descriptive statistics. Results showed that 48% of respondents were within their active productive years (26–45), 90% were female, and 83% were married while 56% had no formal education. The average annual income of respondents was ₦243,333.00 and many (41%) were from Ilorin-West Local Government Area. Technologies known and/or adopted include: bunching, vegetable baskets and vegetable shed. Challenges faced during postharvest handling of green leafy vegetables include: wilting, discolouration with an average storage time of only 25h. Although, high level of awareness (70%) was recorded among holders, there was low level of adoption (less than 40%) of postharvest technologies. Factors responsible for low adoption included: cost, technical know-how and ease of use.
Keywords: *Green leafy vegetable, value chain actors, postharvest losses, technology, Ilorin*

INTRODUCTION
Green leafy vegetables (GLV) are plants with edible leaves, roots or tubers and they are used as supplementary food, side dishes or main stable dishes in Nigeria (Adekalu, 1999). They are functional foods with high nutritional content, essential for growth, health, and good skin (Al Saqqa 2021; Mungofa *et al*., 2022). They reduce risks of obesity, heart diseases, high blood pressure, cancer, and mental decline (Carballido, 2022; Autumn, 2023). They are low in calories, high in fiber, and rich in vitamins A, B, C, E, K, potassium, magnesium, and calcium. Leafy vegetables contain antioxidants like chlorophyll, beta-carotene, and rutin (Shetty *et al*., 2013; Ambuko *et al*., 2017).
Leafy green vegetables, due to their high moisture content, are highly susceptible to postharvest losses (Atanda *et al*., 2011; Workineh and Enyew 2021). According to Elemasho *et al*. (2021), the primary cause of losses is majorly due to inadequate awareness and prevention methods. Other factors include physiological deterioration, mechanical damage, poor handling, diseases, and pest infestation (Atanda *et al*., 2011). Nigeria needs to adopt affordable and adaptable technologies for postharvest loss reduction (Iwuagu *et al*., 2014).
The Nigerian Stored Products Research Institute (NSPRI) has developed some technologies for effective handling of leafy vegetables which include: Vegetable Baskets (VBs) for harvesting, handling and transportation of leafy vegetables, Vegetable Shed for on-farm handling of vegetables and vegetable bunching. Some of these technologies are forms of Evaporative Cooling System (ECS) or controlled atmosphere storage which majorly relate to the environmental conditions of the storage area (Liberty *et al.*, 2013). The VBs as developed can preserve some vegetables for between 5–7 days (Babarinsa, 2001). This study investigated the handling practices of leafy vegetable handlers in Ilorin environs to identify causes of postharvest losses, determine the level of awareness and adoption rate of NSPRI postharvest technologies in the study area and identify the constraints faced by handlers.

MATERIALS AND METHODS

The study was carried out in four (4) Local Government Areas (LGAs). Leafy vegetables sellers and/or holders in the study area constituted the population for data collection in this study with a multistage sampling procedure (Dire *et al*., 2016; Amurtiya and Adewuyi, 2020). The first stage involved purposive selection of four (4) LGAs in Kwara State. The second stage involved purposive selection of five locations (Lasoju, Kodi, Mandate, Ipata and Yoruba road market). The third stage sampling consists of random selection of 30 respondents from each location to make a total of 150. Data were collected from the respondents through the use of structured questionnaires. Descriptive statistics (frequency, percentage and mean) were used for data analyses. Results were presented in tables and charts for clarity and understanding.

RESULTS AND DISCUSSION

The socio-economic characteristics, challenges of storage and level awareness of NSPRI technologies by green leafy vegetable handlers in Ilorin is presented in Table 1. It showed that 29.3% of respondents were between the ages of 26-35 and 19.3% between ages of 36-45 years. Therefore, 48% of respondents are still within the active age and productive years. This corroborates the findings of Elemasho *et al*. (2021). Age is an important factor in the study of individuals because it reflects the physical strength to perform a task and the psychological disposition for imbibing behavioural change or otherwise (Dire *et al*., 2016). The gender distribution was predominantly female, with 90% being married and having a large household size (6-10). This suggests that women are more involved in postharvest activities, which are influenced by division of labour and cultural beliefs (Adejo, 2019). The average annual income of the study population was ₦243,333.00 which apparently is an attraction for the business. The challenges experienced during storage include; wilting and colour change. These challenges could adequately be taken care of by the use of available simple technologies.

The results showed that majority (about 51%) of the respondents have no contact with any extension agents. Further, despite the facts that more than 70% of the respondents were aware of NSPRI postharvest technologies for green leafy vegetables, only few of them had adopted them. The technologies adopted include: bunching (1.3%), vegetable basket (1.3%) and vegetable shed (28%). These results largely indicate that the adoption rate of NSPRI technologies for leafy vegetables is low in the study area. This finding agreed with the report of Adebayo *et al*. (2018) which showed a positive relationship between contact with extension agents and the rate of adoption of technologies. The constraints faced by respondents include; cost (64.7%), technical know-how (19.3%), and ease of use (7.3%).

Table 1. Distribution of respondents according to socio-economic characteristics, challenges of postharvest handling and level of awareness (N=150)

Characteristics	Frequency	Percentage	Mean	Characteristics	Frequency	Percentage
Gender				500,001 and above	5	3.3
Male	14	9.3		No response	15	10.0
Female	135	90.0		Total	150	100.0
No response	1	0.7		**LGA**		
Total	150	100.0		Asa	58	38.7
Age (Year)				Ilorin-East	6	4.0
15-25	19	12.7		Ilorin-South	21	14.0
26-35	44	29.3		Ilorin-West	62	41.3
36-45	29	19.3	41	No response	3	2.0
46-55	29	19.3		Total	150	100.0
56-65	29	19.3		**Do you store?**		
Total	150	100.0		Yes	34	22.7
Marital status				No	110	73.3
Single	14	9.3		No response	6	4.0
Married	125	83.3		Total	150	100.0
Widowed	11	7.3		**If yes, how?**		
Total	150	100.0		Bunching	12	8.0
Household size				Under shed	12	8.0
1-5	47	31.3		Wetting	10	6.7
6-10	91	60.7	7	No response	116	76.5
11 and above	9	6.0		Total	150	100.0
Total	150	100.0		**Challenge during storage**		
Primary occupation				Wilting	69	46.0
Farmer	63	42.0		Colour change	21	14.0
Trader	69	46.0		No response	60	40.0
Farmer and trader	9	6.0		Total	150	100.0
Artisan	7	4.7		**Contact with extension agent**		
Civil servant	2	1.3		Yes	70	46.7
Total	150	100.0		No	76	50.7
Annual earnings (₦)				No response	4	2.6
Below 100,000	5	3.3		**Total**	150	100
100,000 – 200,000	69	46.0		**Awareness of NSPRI Technologies**		
200,001 – 300,000	21	14.0	243,333	Yes	107	71.3
300,001 – 400,000	15	10.0		No	28	18.7
400,001 – 500,000	20	13.4		No response	15	10.0

Source: Field Survey, 2022.

CONCLUSION

The study has shown that indigenous methods of packaging and transportation of leafy vegetables are still in operation among holders in the location visited. Awareness of modern technologies was high but adoption was very low. Among the constraints for lack of adoption of the technologies was cost or finance. Whereas the cost of these items may not be unaffordable for the users, we recommend that more education should be provided to enlighten them about these technologies. The institute should also make some of these materials available to users at subsidized or no cost.

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"LAFIA"

SUB-THEME 9:

Keeping pace with Fisheries and Aquaculture in a Climate Changing World

EFFECT OF DIFFERENT DRYING METHODS ON THE PROXIMATE COMPOSITION OF AQUATIC MACROPHYTES IN SHAGARI DAM SOKOTO STATE

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ABSTRACT

The study investigated the effect of different drying techniques: air, oven and sun drying) on the proximate composition of three aquatic Macrophytes, Common cattails (Typha latifolia), white lotus (Nymphaea lotus) and Oryza sativa. Nymphaea lotus was at 60^{0}C oven dried for 24 hours. Samples of each aquatic macrophytes were and subjected to the three different drying methods in the oven in triplicate. Determination of proximate composition was carried out on the dried sample of each aquatic macrophytes following the methods described by the moisture content of the samples were determined using standard methods. The moisture content of air dried Nymphaea, Oryza sativa, and Typha latipolia leaves are 8.0, 6.0 and 5.5%, respectively. The effect is significant, p=0.5. Relatively high protein content of 16.98, 12.25 and 11.2% were observed for Nymphae lotus, Typha latipolia and Oryza sativa, respectively. Oven dried samples of the three aquatic Macrophytes have the least ash and crude fiber. Research work showed that oven drying is most effective in team of moisture removal and nutrient retention Furthermore, the Study recommends a feeding trial to access the potential of these aquatic Macrophytes subjected to various drying methods on growth and nutrients utilization of cultivable fish species.

Keywords: *Processing methods, proximate composition, Aquatic Macrophytes, Shagari Dam*

INTRODUCTION

Animal's feedstuffs have been in the decline in recent years, because of the diminishing output of certain traditional crops. Statistics show that most country relies on imports to meet the needs of an expanding livestock and aquaculture industry (FAO, 2008). This has caused increase in prices of feed resources which intensify the already high cost of fish feed which have been a major problem to fish farmers in Nigeria (Eyo *et al*., 2004). The feed cost constitute 40 to 60 percent of the recurrent cost of the most intensive fish farm ventures which affect the economic viability of the farm when cheaper alternatives are not available (Madu *et al*., 2003). Fish meal is the most commonly used in fish feed which is consider to be the best in ingredients due to its protein requirement of fish (Alam *et al*., 1996).

Aquatic Macrophytes are among those factors which a fishery manager should try to understand and include in his strategies for optimizing capture fisheries in inland waters. The species composition, distribution and percentage cover of aquatic plants may determine the fish species composition, individual-fish species production, access to fish stocks by fishermen, fishing gear and sometimes also boat access and transport possibilities for getting the fishery product to the markets. Aquatic plant are important component of freshwater ecosystems, affecting diverse ecosystem functions and services (Hilt, *et al.*, 2007), many aquatic Macrophytes species have a high invasion potential due to their high profagule pressure, rapid growth, wide environmental tolerance, high phenotypic plasticity and ability to reduce allelophatic compounds (Riis, *et al*., 2010; Heidbuchel, *et al.*, 2020, Hussner, *et al*., 2021). Macrophytes help to stabilize sediments and shorelines, form breeding ground for some fish and many invertebrate species and are a food source for waterfowl and mammals such as beavers and moose (Walker *et al*., 2013).

Aquatic Macrophytes are present in virtually all freshwater bodies. In lakes they occupy predominantly the littoral shallows, and their importance in a lake ecosystem generally declines with increasing lake size. Emergent and floating-leaved aquatic Macrophytes seldom grow in waters exceeding a depth of 3m (Canfield and Hoyer, 1992) in small lakes where the littoral region with aquatic Macrophytes occupies a literally large portion of the lake;

there is relatively low intensity of competitive interaction among consumers that move from the pelagic zone to use littoral resources (Gasith and Gafny, 1998). The cross-boundary movers are typically adult or large fish that move between deep and shallow water for feeding, cover and seasonally for breeding.
Macrophytes and bryophytes are plants that have structures that are usually more complex, interdependent, and physically substantial than benthic algae. In this chapter, we describe the characteristics and roles of Macrophytes and bryophyte species that can thrive in submerged and flowing conditions. Macrophytes and bryophytes are often important components of stream ecosystems, providing an important physical substrate for periphyton, habitat, and refuges for benthic macro invertebrates and fish, and ultimately detritus that provides food and fuel to heterotrophic bacteria. Individual Macrophytes and bryophyte species are differentially responsive to environmental conditions and have been widely used to define stream community types and to monitor responses of stream ecosystems to terrestrial and anthropogenic drivers. In this chapter, we describe the specific characteristics that define Macrophytes and bryophytes, discuss their role in stream ecosystems, and provide instructions for common methods to sample them. Macrophytes may be used as fish food components and replace costly commercial feed owing to their potential nutrients profile: moisture ranges between 84.1-95.9%, dry matter 4.1-15.9%, crude protein 8.7-26.8%, crude fat 2.2-5.1%, carbohydrate 9.3-35.6%, ash 8.0-25.3%, and crude fibre 15.0-28.1%. The objective of the study is to assess the effect of different drying methods on the chemical composition of aquatic Macrophytes in Shagari Dam, Sokoto State.

MATERIALS AND METHODS

Description of the Study area

The study was carried out at the Shagari Dam and Agric Chemical Laboratory of the Faculty of Agriculture, Usmanu Danfodiyo University, Sokoto. The experimental site is located in Sudan Savanna vegetation zone of Nigeria on latitude 13° 07' 78 N and longitude of 5° 12' 25" E and on 275m above sea level. The study area is characterised by a long dry season which start from October to May, 2022; with cool dry air during the harmattan; (November - February) and hot dry air during (March - May). Raining season start in June and ends in September. Annual rainfall in the area ranged from 500 to 725mm. The mean relative humidity range between 14.9% and 40% during March and June, 2022, respectively. The ambient temperature can reach up to 41° during April and May and may fall 20°C during December and January.

Sample Collection

Samples were collected from Shagari Dam, Shagari local government Sokoto, Sokoto state, around the study area.

Identification of Sample

The samples collected were identified using a book written by Akobundu and Agyakawa (1987).

Processing of Macrophytes

Sun drying

The samples were dried on clean concrete surface flour to prevent being blown away by wind. Samples were sun-dried for 8 hours, at a relative humidity of 780 mm HG and the temperature readings were as follows: 30.25^{0}C, 34.50^{0}C, 35.23^{0}C, and 34.750C at 10am, 12.00pm, 4.00pm and 6.00pm respectively. This was aided by the use of mercury glass thermometer.

Air drying of samples

The samples were air dried indoor and the temperature was monitored. A building, room, etc., where goods or materials are dried in an artificially raised temperature; a drying-chamber. Temperature readings were 29^{0}C, 32.5^{0}C, 30.5^{0}C, 29.8^{0}C at 6.00am, 12.00pm, 4.00pm and 8.00pm respectively. This was aided by the use of Mercury glass thermometer.

Oven drying

The oven drying samples were oven dried at the Agric. Chemical Laboratory using UniscopeSM9053 Laboratory Oven at 65^0 C for 48hrs.

Proximate Analysis

Samples collected were analysed using the A.O.A.C (2000) methods. The proximate composition analysed were moisture content (Mc), ash content, crude protein (Cp), ether Extract (EE), Crude fiber (Cf), and the carbohydrates contents (CHO).

Moisture content (Mc)

Empty can (Petri dish) was weighed empty (W_0) and 2g of a Macrophytes sample were added and weighed (W_1) again. The W_1 was placed in the hot air drying oven at 105°c for 24hours and then allowed to cool off in a desiccator. The dried sample was weighed again (W_2) and then returned back into the oven for another 24 hours to maintain a constant weight. The weight (W_2) was constant and the moisture content was calculated as:

$\%MC = W_1 – W_2/W_1 –W_0 \text{ X } 100$

Crude Protein (Cp)

The estimation of Crude protein involved the determination of total nitrogen usually by the Kjedahl procedure (Digestion, Distillation, and Titration).

%Nitrogen = TV x 0.01m x 0.014m x 50x100/ Weight of sample x Mol. of aliquots

The crude protein was determined by multiplying the nitrogen value by 6.25.

Ether Extract (EE)

A known weight of prepared sample was poured into a thimble and covered with a cotton wool and the thimble was placed into the Soxhlet apparatus, before this was carried out, the thimble was washed, dried and weighed (W_1). Petroleum ether was added into the flask and heated to extract the fat from the sample for 7-8 hours. The lipid is then collected from the flask and dried in the oven for 1 hour at 100-105^{0}C, the flask is then weighed again together with the lipid (W_2). The percentage lipid is calculated thus

%EE =W_2 –W_1/weight of sample x 100

Crude fiber

A known weight of sample was poured into one liter conical flask and 200ml of boiling 1.25% H^2SO^4 was added and boiled for 30 minutes using cooling fingers to maintain constant volume. The sample was then filtered over a 9cm Buchner funnel and rinsed with hot distilled water and 10% was added and rinsed with petroleum ether (BP 40-60^{0}C). The residue was dried overnight in oven at 100^{0}C and cooled in a desiccator (W_1); this was then ashed at 550^{0}C for 90 minutes in a muffle furnace and cooled in a desiccator before weighing again (W_2). The percentage crude fiber was calculated using

%Cf= W^1-W^2/weight of sample x 100

Nitrogen Free Extract

This was not determined directly but was obtained as the difference between the crude protein and the sum of Ash, protein, crude fat and crude fiber.

Nitrogen free extract (NFE) =100- (%Ash+%Cf+%EE+%CP)

Statistical analysis

The determination was made in triplicate, parameters obtained were subjected to analysis of variance (ANOVA) and, the treatment means was separated for significant differences following the procedure of Duncan Multiple Range Test (Steel and Torrie, 1980). All the analysis was carried out using the computer software Statistical Package for the Social Sciences (SPSS) version 9.0 windows (SPSS, 2007).

RESULTS AND DISCUSSION

Proximate Composition of Water lily common cattails and *Typha latifolia*

Result of the analysis showed oven dried and sun dried samples with the lowest moisture content compared to air dried samples. The effective moisture removal for Nymphaea leave is in the order of air dried>oven dried, sun dried. The results also showed that Nymphaea leaves had crude fiber content within the range of 3.0 to 18.5 which is in order of sun dried>air dried>oven dried. Similar trend was also reported in the leaves of *Cratera religiosa* (Hassan *et al*., 2007).

Results of the analysis showed that oven dried and sun dried samples with the lowest moisture content compared to air dried samples. The effective moisture removal for Typha leave is in the order of air dried>oven dried and sun dried. The results also showed that Typha leaves had crude fiber content within the range of 35.5 to 39.5 which is in order of oven dried>sun dried>air dried.

Results of the analysis showed that sun dried and oven dried and samples with the lowest moisture content compared to air dried samples. The effective moisture removal for Oryza leave is in the order of air dried>oven dried>sun dried. The results also showed that Typha leaves had crude fiber content within the range of 21.5 to 35.5 which is in order of air dried>oven dried>sun dried.

Aquatic Macrophytes leaves

The investigation showed that some fish species feed on some plants. This was in line with Opuszyski (1972), who said herbivorous fish feeds on aquatic plants. Another writer Shell (1962) also writes that certain species feed on aquatic plants. Although Boyd (1968), Bates *et al*. (1976), Oyakawa *et al*. (1965) and Scunthorpe (1967) writes on different aquatic plants eaten by man, most of the mentioned plants were not however found here. But Scunthorpe (1967) writes on different aquatic plants eaten who he said the seeds, rhizomes and petioles of Nymphaea species.

Gaevskaya (1966), Moore (1969) and Sharma (1971) also wrote on the uses of aquatic Macrophytes as livestock feed. Other uses are included in this write up which was not explained by the writers. Aquatic Macrophytes harbour certain pests and diseases. Aquatic Macrophytes have been to serve as foodfor livestock, and could also serve as host for pest and disease (Uka and Chukwuka, 2011).

Macrophytes serves as fish hideouts, fish nets, reduces catch. Breeds mosquitoes and causes malaria was higher (80%).

Obeng (1969), Or *et al.* (1987), Baker *et al*. (1984), Pet (1968), Paperna (1970) and Odei (1979) among other writers on the effects of aquatic Macrophytes which confirms results obtained from the study. Weight of aquatic Macrophytes varies due to their differences in their different moisture content. This is because their classification varies as some are free floaters while others are emergent. The mineral composition varies also among aquatic Macrophytes. A good reason is because of the environment where they are found and also the type of plant. National Council for research (1976) writes on the chemical composition of aquatic Macrophytes which results of obtained from the analysis is similar.

Table 1 Proximate composition of Sample ingredients in **different drying methods**

Aquatic Macrophytes	Nutritional values %					
	Moisture	Ash	Lipid	Fiber	Protein	NFE
Typha latipolia						
Air dried	8.0[a]	10.0[a]	1.5[a]	35.5[a]	10.15[b]	35.85[b]
Oven dried	4.5[b]	5.0[c]	1.5[a]	39.5[a]	12.25[a]	37.25[a]
Sun dried	4.5[b]	7.5[b]	1.5[a]	36.5[a]	11.73[a]	38.27[a]
	SE=0.63	SE= 0.75	SE = 0.10	SE= 3.64	SE = 0.37	SE = 0.40
Nymphaea lotus						
Air dried	5.5[a]	14.5[a]	2.0[a]	19.5[b]	16.98[a]	41.52[c]
Oven dried	4.0[b]	12.5[b]	2.0[a]	12.0[c]	16.98[a]	52.52[a]
Sun dried	4.0[b]	3.0[c]	2.0[a]	26.5[a]	16.1[a]	48.4[b]
	SE = 0.28	SE= 1.78	SE = 0.14	SE= 2.10	SE = 0.20	SE = 1.61
Oryza sativa						
Air dried	6.0[a]	12.5[c]	1.5[a]	35.5[a]	12.6[a]	33.9[c]
Oven dried	5.0[ab]	15.5[a]	1.0[a]	22.0[b]	11.2[a]	45.3[b]
Sun dried	4.5[a]	14. 0[b]	1.0[a]	21.5[b]	7.88[b]	51.12[a]
	SE = 0.28	SE= 0.48	SE = 0.16	SE= 2.30	SE = 0.73	SE = 2.53

Values in a column denoted by same letters are not significantly different (P>0.05).

CONCLUSION

The results of this study shows that *Nymphaea lotus* leaves and *Oryza sativa* leaves are good sources of carbohydrate and moderate protein. However, *Typha latifolia* had relatively low carbohydrate lipid and lower protein contents together with *Oryza sativa*. drying methods were found to have effects on moisture, ash, crude fiber, crude protein crude lipid and soluble carbohydrate in all the three aquatic Macrophytes, but protein retention was highest in oven dried samples.

RECOMMENDATIONS

Research should be carried out on these leave as possible source of feed for fish and other uses. Enlightenment should be carried out to keep the communities around the study area at alert and inform the public benefits behind the maximum utilization of these plants. Based on the findings the following recommendations were drawn: It is recommended that drying under shade be adopted for drying these leaves.

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ANALYSIS OF CRAYFISH MARKETING IN BONNY LOCAL GOVERNMENT AREA, RIVERS STATE. NIGERIA.

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ABSTRACT
The study examines the analysis of crayfish marketing in Bonny Local Government Area of Rivers State. A total of 110 respondents made up the sample size for the study. Data were collected using copies of structured questionnaire and analyzed using descriptive statistics such as frequencies, percentages, mean score Likert scale, and gross margin. Results from the study showed that majority (94.5%) of the respondents were female and most (50%) of them were between the age of 31-43 years and also 73.6% of the respondents received formal education. Further findings showed that 67.3% of the sampled respondents earned ₦41,000-₦80,000 per month while 22.7% of them earned between ₦10,000-₦40,000 per month. Results on the methods of crayfish processing showed that the most common method were sorting and salting which had 21.3% and respectively. Gross margin analysis showed that a monthly average gross margin earned in the study area was ₦72508.77 and the profit stood at ₦75939.49. In respected to the constraint to crayfish marketing, results from the mean score showed that, the most prevalent constraint to crayfish preservation was the inhaling of Co2 (means score 3.381818) and that for crayfish marketing was price fluctuation (mean score =3.272727). The study recommended that Medical outreach should be organized to crayfish marketers/processors to assess the level of harm CO_2 causes to their health and educate them about the dangers of CO_2, and further suggesting preventive measures to the effect of CO_2.
Keywords: *Crayfish marketing, Crayfish processing, Costs and returns*

INTRODUCTION
Crayfish is one of the aquatic animals and dominant decapods in many freshwaters and even terrestrial habitats playing important community roles through their wetlands (burrowers), and cave ecosystems (Reynolds et al., 2013). Being an important crustacean consumed all over the world, they are usually prepared for consumption by smoking, and occasionally preserved by sun-drying. It is also a common delicacy in the diet among the people of the Southern Western Nigeria (Chinasa, 2017). It is a clean and very low carbohydrate food and has a super healthy combination of nutrients from its almost pure form of protein to its healthy amount of omega-3 fatty acids which we now know are among the most beneficial fats we can eat (FAO, 2009). Meals containing crayfish play a great role in the development of humans in the world especially in the lives of people in the developing countries where other protein sources are grossly inadequate and comparatively costly (Ele and Nkang, 2014). Experimentally, protein derived from crayfish and fish-based diet is as good as that obtained from meat. Consumption of crayfish together with products of plants origin which are poor in some amino acids such as lysine and thiamine enables not only a complete utilization of plant protein, but also improves the content of the diet (Ele and Nkang, 2014). Crayfish key roles and attributes in ecosystems include indicators or surrogates for water quality, bio-indicators for communities or habitats, keystone controllers of trophic webs and ecological engineers.
Crayfish has been used as a major source of income because of its high demand in the markets. Its market shifted from local consumption in rural areas to higher volume markets in cities such as Baton Rouge, New Orleans and beyond (Taylor, 2009). In the study area (Akwa-ibom State, Nigeria) crayfish has provided business and economic activities for the fishermen, crayfish dealers as well as consumers of crayfish (Ele and Nkang, 2014). It is estimated that about 12,000 metric tonnes of crayfish is produced annually in Nigeria and although the artificial rearing and

production of crayfish in Nigeria is not common compare to the production of fish, processing and marketing of crayfish is gaining ground because of the seasonality of supply with the peak harvest occurring 891from March through June (Robert *et al*., 2005). Marketing of crayfish passes through various market participant and exchange of crayfish point before they reach the final consumers (Baba *et al., 2015)*. The longer the chain of people involved in a marketing process, the more the costs incurred.

The demand for crayfish globally in Nigeria has been on the increase with the supply not meeting up with the demand (FAO, 2004) even though, especially inthe knowledge that Nigeria is blessed with a vast expanse of inland fresh waters and marine brackish ecosystem, which are very rich in aquatic life (Chukuigwe *et al.*, 2021; Tall,2004). It is estimated that about 12,000 metric tonnes of crayfish is produced annually in Nigeria and although the artificial rearing and production of crayfish in Nigeria is not common compared to the production of fish, processing and marketing of crayfish is from March through June (Robert et al, 2005). Thus, there is need to strike a balance between production (catching, processing, and marketing) and consumption of crayfish. One of the ways of doing this is by improving the processing and marketing system, since production, processing and marketing work together. (Mendoza and Rosegrant, 2000). The specific objectives of this study were to:

i. describe the socioeconomic characteristics of crayfish marketers;
ii. identify the methods of crayfish processing prevalent in the study area;
iii. estimate the costs and returns of crayfish marketing in the study area; and
iv. identify the constraints associated with crayfish processing and marketing in the study area.

METHODOLOGY

The study was conducted in Bonny Local Government Area (LGA), Rivers State Nigeria. Bonny Local Government Area of Rivers State is situated in South Nigeria. It is on the Bight of Biafra within latitude $4^0 26^1 0^{11}$N and Longitude 7^0 $10^1 0^{11}$ E. It is approximately 56 km from upland Port Harcourt, the capital city of Rivers State Niger Delta (Abere & Opara, 2018 cited by Harry and Brown, 2020). The LGA was estimated to have 215,358 inhabitants in the 2006 national census (NPC, 2006). Boats are the main form of transport to and from the island. The local language spoken in Bonny Island and Bonny Town is Ibani, though many natives there also speak Igbo language.

Survey research design was employed in this study where copies of structured questionnaire was used to generate data. According to the information gathered from Crayfish union in 2022 there are 151 registered Crayfish marketers in the Bonny LGA. *Taro Yamene Formula* was employed in determining the sample size of 109 marketers. However, for the purpose of equal allocation across the 10 communities in the study are, the study thus increased the sample size to 110 marketers. Multi-stage sampling was used in selecting the sample size of the study. In the first stage, the purposive selection of ten (10) communities out of the seventeen (16) communities in Bonny LGA was employed. This was owing to the fact that there was more Crayfish marketers concentrated in them. The second stage involved the simple random selection of eleven (11) crayfish marketers respectively across the following communities; Adamakiri, Agbala, Akpakpasu, Amanadama, Biemekiri, Bilemekiri, Atabakiri, Alaasiakiri, Asaramatoru, thus making a total of 110 respondents. In respect to the analysis of the data, objective (i) as achieved using tabular presentation of frequency distribution, and percentages. Objective (ii) and (iv) were achieved viz., 4 point Likert scale, and. objective (iii) was achieved using gross margin analysis.

Likert Scale Rating Technique

The study utilized the 4-point scale rating technique presented in the following order:

Strongly agreed (SA) = 4; agreed (A) = 3; disagree (D) = 2; strongly disagree (SD) = 1.

The mean scores of the respondents based on the 4-point scale would be 4 + 3 + 2 + 1 = 10, 10/4 = 2.50.

Benchmark: The benchmark using the four- point Likert Scale to analyze the constraints militating against pepper production was 2.5. The 2.5 constraint benchmark indicated the constraints that militated against farmer's production, mean values from 2.5 and above shows that the parameter is a constraint.

Gross Margin

Gross margin mode was used to determine the costs and returns from gross margin obtained; further analysis was conducted to obtain profit associated with the trade in the study area. The model is specified as:

GM = TR – TVC……………………………………………………………………eq 1.

Where: GM = Gross margin; TR = Total revenue; TVC = Total variable cost; TFC = Total fixed cost; and π (profit) = GM- TFC

RESULTS AND DISCUSSION

Socio-Economic Characteristics of the Respondents

The result from Table 1 shows that 94.5% of the respondents were females, while 5.5% of them were male. On age, it shows that 50% of the respondents were between the ages of 31-43yrs, 24.5% of them were between the ages of 18-30 years, 20.09% of them were between the ages of 44-56 years and 4.5% of the respondents were between the ages greater than 57yrs. This implies that majority of the marketers were young and vibrant people who could carry out the tedious work involved in crayfish marketing. Individuals who are in their active ages have the tendency to be more productive (Olasunkanmi *et al.*, 2012; Agbagwa, *et al*, 2021). Entries on marital status showed that 72.7% of the respondents were married, 20.9% of them were single and 6.4% of then were separated.

Furthermore, Table 1 shows that on the household of the respondents, 53.6% of the respondent had household size of 5-7 persons, 31.8% of them had household size of 2-4 persons 10% of them had household size of 8-10% and 4.5% of them had household size greater than 10 persons. This indicates that majority of the respondents had household size of 5-7 persons. This result also shows that since they had a large household size, they had the responsibility of taking care of them. Entries on years of experience showed that majority (59.1%) of the marketers had 4-6 years marketing experience followed by 20.9% of them who had 1-3 years of experience. Sadiq *et al.* (2015) posited that experience enhances risk management. Entries on educational attainment show that majority (53.6%) of the respondents had secondary school educational attainment while 26.4% of them received no formal education. On monthly income earned by the marketers, 67.3% of the respondents earned ₦40,000-₦80,000, 22.7% of them earned ₦10,000-₦40,000, 5.5% of them earned ₦81,000-₦120,000, and 4.5% earned greater ₦120,000.

Table 1: Socio-Economic Characteristics of Respondents (n = 110)

Characteristics	Frequency	Percentage (%)
GENDER		
Male	6	5.5
Female	104	94.5
Total	110	100
AGE (Years)		
18-30	27	24.5
31-43	55	50
44-56	23	20.9
> 57	5	4.5
Total	110	100
MARITAL STATUS		
Married	80	72.7
Single	23	20.9
Separated	7	6.4
Total	110	100
HOUSEHOLD SIZE (Person)		
2-4	35	31.8
5-7	59	53.6
8-10	11	10
>10	5	4.5
Total	110	100
FARMING EXPERIENCE (Years)		
1-3 years Secondary	23	20.9
4-6 years	65	59.1
7-9 years	11	10
> 9 years	11	10
Total	110	100
EDUCATIONAL ATTAINMENT		
No formal education	29	26.4
Primary	22	20
Secondary	59	53.6
Tertiary	0	0
Total	110	100
Monthly Income (₦)		
10000-40000	25	22.7

41000-80000	74	67.3
81000-120000	6	5.5
>120000	5	4.5
Total	110	100

Field Survey, 2022

Methods of Processing Crayfish

Result in Table 2 shows that 21.30% of the marketers utilized sorting as one of the methods in the processing of crayfish. In addition, 20.40% and 18.80% respectively utilized salting and smoking of crayfish as methods of crayfish processing. While 18.80% marketers engaged in washing 10.20% utilized cleaning while 10.40% employed sun drying as one of the methods of crayfish processing.

Table 2: Methods of Crayfish Processing Prevalent in the Study Area

Method	N	Percent	Percent of Cases
Smoking	85	18.80%	77.30%
Sun drying	47	10.40%	42.70%
Salting	92	20.40%	83.60%
Washing	85	18.80%	77.30%
Cleaning	46	10.20%	41.80%
Sorting	96	21.30%	87.30%
Total	**451**	**100.00%**	**410.00%**

NB Multiple response (i.e. respondents were allowed to choose one or more answers from the list)

Source: Field Survey, 2022

Profitability of Crayfish Marketing

The result in Table 3 shows that variable cost of marketing per month was ₦151,611. Total revenue was ₦224119. The Table further shows that ₦72508.77.00 was obtained as the gross margin (GM=TR-TVC). The average monthly profit form crayfish marketing in Bonny LGA was ₦75,939.49. This is evident that the marketing of crayfish in Bonny is profitable. More so, the rate of return of return on investment was ₦1.45 which would imply that for every ₦1 invested in crayfish marketing, ₦1.45 was gained by the marketer.

Table 3: Average Monthly Costs and Returns on Crayfish Preservation and Marketing

ITEM	AMOUNT (₦)
Total Revenue (TR)	**224119.8**
Crayfish	112554.6
Transportation	6650.909
Packaging material	4238.182
Firewood	10072.73
Salt	565.3061
Kerosene	2798.182
Tax	14792.73
Total Variable Cost (TVC)	**151611**
Gross Margin (GM)	**72508.77**
Depreciation	112.0833
Shop rent	3318.636
Total Fixed Cost (TFC)	**3430.72**
Total Cost (TC)	**155041.7**
Profit	**75939.49**
Net return on Investment (NROI)	**1.45**

Source: Field Survey, 2022

Constraints to Crayfish Preservation

The constraints to crayfish processing are presented in Table 4. The result shows that inhaling of carbon dioxide (CO_2), undesirable odour and drudgery were seen by the marketers as a constraints as they had mean scores greater than 2.50. The marketer also admitted that drudgery associated with the processing of crayfish was a constraint in the business. In another vein, lack of processing facilities, inadequate knowledge and lack of finance were not considered as constraints as they had mean scores less than 2.50.

Table 4: Constraints to Crayfish Processing

Constraints	**SA**	**A**	**SD**	**D**	**Total Score**	**Freq.**	**Mean**
	4	**3**	**2**	**1**			**($\bar{X}$)**
Lack of processing facility	20	48	136	21	225	110	2.045455
Inadequate knowledge	0	18	126	41	185	110	1.681818
Inhaling of CO2	232	132	0	8	372	110	3.381818
Undesirable odour	104	195	30	4	333	110	3.027273
Drudgery	40	255	10	10	315	110	2.863636
Lack of finance	36	75	70	41	222	110	2.018182

$\bar{X}$ >= 2.50 = important; $\bar{X}$ < 2.50 = unimportant

Where: SA = Strongly Agree A = Agree, D = Disagree, SD =Strongly Disagree

Source: Field Survey, 2022

Constraints to Crayfish Marketing

The constraints to crayfish marketing as identified by the respondents are presented in Table 5. The result shows that poor infrastructure, price fluctuation and loss of capital due to debtors were considered by the marketers as constraints to the trade as they had mean scores greater than 2.50. This indicates that poor infrastructure, price fluctuation and loss of capital due to debtors were the major constraints to crayfish marketing in the study area. However, marketing location and perishability were not seen as constraints.

Table 5: Constraints to crayfish marketing

Constrains	**SA**	**A**	**SD**	**D**	**Total Score**	**Freq.**	**Mean**
	4	3	2	1			**($\bar{X}$)**
Poor infrastructure	20	150	110	0	280	110	2.545455
Marketing location	60	60	140	5	265	110	2.409091
Price fluctuation	160	180	20	0	360	110	3.272727
Perishability	0	18	124	42	184	110	1.672727
Loss of capital due to debtor	164	117	60	0	341	110	3.1

$\bar{X}$ >= 2.50 = important; $\bar{X}$ < 2.50 = un important

Where: SA = Strongly Agree A = Agree, D = Disagree, SD =Strongly Disagree

Source: Field Survey, 2022

CONCLUSION

The study showed that that crayfish marketing is profitable in Bonny LGA and is highly dominated by females. The most dominant method used in the processing of crayfish in the study area was sorting. The study further adds that while inhaling of CO_2, undesirable odour stood as the major constraint to crayfish processing, Price fluctuation and Poor infrastructure were adjudged the major constraints to crayfish.

RECOMMENDATIONS

Based on the findings obtained, the study recommends that:

i. Medical outreach should be organized to crayfish marketers/processors to assess the level of harm CO_2 causes to their health and educate them about the dangers of CO_2, and further suggesting preventive measures to the effect of CO_2.

ii. Modern processing facilities that emits less of CO_2 be provided to the marketers to enable them process crayfish with lesser health risk.

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EFFECT OF ARTISANAL FISHERIES ON LIVELIHOOD OF FISHING COMMUNITIES ALONG KAINJI DAM AREA IN YAURI LOCAL GOVERNMENT, KEBBI STATE, NIGERIA

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ABSTRACT

This study assessed the effect of artisanal fisheries on the livelihood of fishing communities along Kainji dam, Nigeria. Questionnaire schedule was used to collect data from 460 respondents. Multi-stage and proportionate sampling techniques were used in selecting the respondents. Descriptive statistical tools (frequency distribution count, percentages and mean) and inferential statistics (logit regression) were used for data analysis. The Logit regression estimates of the effect of artisanal fisheries on livelihood sustainability status of the fishers shows that the coefficients with respect to household size X^1, access to credit X^2, age X^3, fishing experience X^4, livelihood diversification X^5 and income from fishing X^6 were statistically significant at 1% level of significance while access to extension X^7 was significant at 5% level of significance. The estimated fish catch per unit effort has declined to less than 2 kilograms compared to more than 8 kilograms realized by 42.5% of the fishermen before the establishment of the dam. In conclusion, the research showed that, artisanal fishing activity is important in the lives of the fishers along the two dams and thus need to be sustained. The study therefore, recommended that financial institutions should grant credit facilities to practicing fishers with easy collaterals.. Government should provide improved fishing and processing postharvest inputs to fishers at subsidized rate to avoid spoilage during storage and transportation. Fisheries extension agents should facilitate awreness and adoption of improved fishing techniques.

Keywords: *Effect, Artisanal Fisheries, Livelihood, Fishing Communities, Kainji Dam*

INTRODUCTION

The fisheries subsector of the Nigerian agriculture is an essential tool for rural development through its provision of income, high-quality protein, and socioeconomic development of fishing communities in Nigeria (Anko and Eyo, 2001). The relevance of the fisheries sub-sector to the Nigerian economy and benefits derived by Nigerians from fish and other fish products has led to the high consumption and hence the increased demand for fisheries products. In order to meet up with increasing demand for fisheries products, Nigerian federal government have tremendously implemented series of projects targeted at increasing the local supply of fish. Some of the projects include second and third phases of Fadama programme, source although some improvements were recorded in terms of output levels of fish, the gap between the demand and supply of fish keeps increasing as a result of the use of traditional fishing methods, as is the artisanal fishery, which has the major source of protein from fish relied on, despite the increasing growth rate of the Nigerian population. Fisheries production in Nigeria especially from marine is important for the socio-economic development of Nigerians and it contributes to the nation's economic growth through the Gross Domestic Product (GDP) (Shehu and Kafayat, 2017).

METHODOLOGY

Kainji Lake is located between latitudes 9°5' and 10°55'N and longitudes 4°21' and 4°45'E. It cuts across the Niger and Kebbi states, and is mostly located in Niger state. Kainji is the second largest lake and the largest man-made lake in Nigeria (Umar and Illo, 2014). It was created in 1968 following the impoundment of the Niger River by the construction of the Kainji Dam at New Bussa, in Borgu Local Government Area of Niger State. It has a maximum length of 134km, a maximum width of 24.1km, a mean and maximum depth of 11m and 60m, respectively, a surface area of 1,270sqkm, a volume of 13 × 10^9m^3, and a catchment area of 1.6 × 10^6sqkm. The climate of the Kainji Lake usually alternates between dry and rainy conditions. The total annual rainfall for the Lake ranges between 1,100 mm and 1,250 mm, spreading from April to October (Salami *et al.*, 2011). The highest (about 30°C) and the lowest (about 25°C) monthly temperatures are recorded in March and August, respectively. Fishing is the major traditional occupation of these people whereas other occupations include: farming, livestock breeding and local entrepreneurship such as pottery, mat weaving, gear/craft making and servicing (Alamu, 2000). Both primary and secondary data were used for the study. The study identified 550 fishing communities along Kainji dam. The fishing communities have a fishing population of 3,823 along Kainji. This figure 3,823) represents the sampling frame out of which the sample size of the study was drawn. The study employed multi-stage and proportionate sampling techniques. Firstly, Kainji dam in North central region where artisanal fisheries activities are widely practiced was purposively selected. Secondly, 50 Villages were randomly drawn along Kainji dam for the study. Thirdly, proportionate sampling technique was then employed to select 460 respondents along the dam to be used as the sample size for the study.

Data were analyzed using both descriptive and inferential statistics. Descriptive statistics such as frequency distribution count, percentages and mean were used to analyze objectives 1. Similarly, Logit registration were used to analyze objectives 2.

Logit Regression Analysis

Specification of the Model

Logit Regression Analysis (LRA) was employed to analyze objective 2. The Logit model is an inferential statistical regression model that describes the relationship between a censored continuous dependent variable y_i and a vector of independent variables x_i (Amamiya, 1998).

Y_i is the dependent variable and X_{i} – X_{14} are the independent variables

The general Logit regression model is mathematically expressed as:

$Y = \alpha + \beta o + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \ldots + \beta_{11} X_{11} + U$………………. (1)

Where Y = Livelihood (Implying a binary dependent variable valued as 1= when household has sustainable livelihood and 0= when otherwise.

X_i =Fishing technology (1 for local, 2 for modern, 3 for combined)
X_2 =Income from fishing (₦)
X_3=Processing method (1 for traditional processing method, 0 for otherwise)
X_4=Quantity of fish caught (Kg)
X_5=Household size (Number)
X_6=Period of fishing (1 for dry season, 0 for otherwise)
X_7=Experience in fishing (Years)
X_8= Membership of association (1 for member, 0 for otherwise
X_9=Access to credit (1 for access, 0 for otherwise)
X^{10}= Access to extension (1 for access, 0 for otherwise)
X_{11}= Age of fishers (Years)
X^{12} = Packaging method (1 for local, 2 for modern)
X^{13} = Livelihood diversification (1 diversified, 0 no diversification)
X^{14} = Distance to fishing site (Km)+
U=Error term
βi =Constant term
$\beta i - \beta_{10}$=Regression coefficient to be estimated (Amamiya, 1998).

RESULTS AND DISCUSSION

Table 1 shows the logit regression estimates of the effect of artisanal fisheries activities on livelihood sustainability of fishers along Shiroro and Kainji dams. The study found that artisanal fishing is a viable and a profitable enterprise capable of providing employment opportunities among the fishing communities of the two dams. The model predicted the livelihood sustainability status of fishers with 85.3 percent accuracy, according to the results of the logit regression provided in Table 1 in terms of predictive efficacy. The results also demonstrated that in understanding the effect of artisanal fisheries activities on livelihood sustainability status, the model was adequate. Six of the eleven factors in the model (Household size, Access to credit, Age, Fishing experience, Quantity of fish caught, Income from fishing) were found to be significant at 1% level of significance and one other variable (Access to Extension) was significant at 5% level in explaining the variation in the livelihood sustainability status of fishers in the study area. Household size of the fishers has a negative coefficient but statistically significant (t = -3.42, p0.01). As a result, the effect of artisanal fisheries on livelihood sustainability of the fishers in households would decline as the size of the household increased. A unit increase in the size of the household will result in a 0.06 reduction in the likelihood that livelihood will be sustainable. This outcome was anticipated because more homes means more people are consuming the same resources. Larger households experience unsustainable livelihood more frequently than smaller ones (Jared, 2021). This findings is in line with Umunna *et al.*, (2020) who reported that the household size of the respondents was observed to have a positive significant ($p<0.1$) influence on the likelihood of livelihood sustainability. The coefficient of household size have a positive and significant relationship with the possibility of the fisher's household's livelihood sustainability. This study is in congruence with the findings from previous similar studies (Toyosi *et al.*, 2019). The marginal effect of household size revealed that the likelihood of livelihood sustainability will increase by 4.3% with an additional member in the household. Findings of this study agrees with that of Ifeanyi-obi *et al.*, (2018) who confirm a positive association between household size and on-farm livelihood sustainability. The results show further that for every unit increase in household size, there is a 0.83 increase in the log odds of on-farm livelihood sustainability by households, holding all other independent variables constant. These findings suggest that as household size increases, so does on-farm livelihood sustainability. The model confirms a positive association between the fishing experience and livelihood sustainability of the fishers. The results indicates that for every unit increase in the years of fishing experience of the fishers, there is a 0.06 increase in the log odds of livelihood sustainability, holding all other independent variables constant. These findings therefore suggest that as years of fishing experience increases, so doe's livelihood sustainability.

Access to extension contact has a positive coefficient ($t = 2.17$, p 0.05) that is significant at 5% level. This outcome is anticipated since extension agents are expected to communicate information and/or enlighten fishers on improved fishing technologies that can enhance productivity (fish catch) of the fishers. This is in turn expected to translate to a higher income and livelihood sustainability. This result is in disagreement with the result of Ismail (2014) who reported that the coefficient of extension contact correlated negatively with livelihood sustainability with a t-value of 2.476 which was significant at both 0.01 and 0.05 probability levels respectively. This implies that the more the rural dwellers come in contact with extension agents the more they engage into other livelihood activities. The model results confirm a positive relationship between access to credit and fishers livelihood sustainability. The results showed that holding all other independent variables constant, for every unit increase in credit accessibility, there is a 1.67 increase in the log odds of livelihood sustainability of the fishers. It is believed that access to credit promotes the use of risky activities through relaxation of the liquidity constraint as well as through boosting of a household's risk-bearing ability. With an option of borrowing, a household can do away with inefficient risk reducing income diversification strategies and concentrate on more risky but also more efficient investments.

The coefficient of age of household has been found to have a significant ($t<4.24$) and negative influence on the probability of livelihood sustainability. In other words, the multiplicity of livelihood activities the fishing households engage in decreases with advancing age. This study in in congruence with George *et al.*, (2012) who reported that the age of the fishers positively and significantly affect income at 5% level of significance with coefficient of 0.004 and p value of 0.001. This implied that the income of the fishers increased by 4% as the fishers age increased by one year. The coefficient of monthly income correlated positively with livelihood activity with a t-value of 2.21 which was significant at 0.01 probability level. This could imply that rural dwellers who earn higher monthly income have their livelihood activities enhanced and sustained other than fishing. This may be as a result of having more money which can enable them invest in other livelihood activities other than fishing.

Table 1: Logit regression estimates of the effect of artisanal fisheries on Livelihood sustainability of fishers (n = 460)

Variables	Parameters	Coefficient	Standard Error	t-Value
Period of fishing	X^1	0.041	0.161	0.26
Household Size	X^2	-0.063***	0.018	3.42
Membership of Association	X^3	0.179	0.255	0.70
Access to Extension	X^4	0.713**	0.328	2.17
Access to Credit	X^5	1.647***	0.461	3.57
Fishing Technology	X^6	-0.139	0.205	-0.68
Processing Method	X^7	0.062	0.399	0.15
Age of the Fishers	X^8	0.0009***	0.000	4.24
Fishing Experience	X^9	0.060***	0.022	2.77
Livelihood diversification	X^{10}	1.848***	0.449	4.12
Income from fishing	X^{11}	0.655***	0.297	2.21
Lr Chi^2			268.19	
Prob > Chi^2			0.00	
Pseudo R^2			0.85	
Log Likelihood Value			-23.06	
Number of Observations			460	

Source: Field Survey, 2023 *significant at 10% level, **significant at 5% level, ***significant at 1%level

Result from table 2 shows that majority of the respondents (42.5%) indicated that their fish catch per unit effort before the establishment of Kanji Dam was more than 8 kilograms while majority (47.5%) of the respondents indicated that their fish catch per unit effort after the establishment of the dam was less than 2kg. The result of the study agreed with the findings of Ita (1982) who reported that early fish yield after the impoundment reached 28,639 metric tons in 1970, after which the yield declined to 4,500 metric tons in 1978 (Ekwemalor, 1978). Balogun (1985) attributed the decline in fish catch per unit effort to presumed increase in fishing pressure and use of undersized fishing gears. As a result, Juvenile of most fish species are indiscriminately accepted, thus preventing smaller fish to grow to adult or marketable size. Results of the study also showed that 71.9% of the respondents who engaged in fishing attributed the declining fish catch recorded over the years to construction of Kainji dam while 28.1% attributed it to the migratory fishermen who engaged in massive fish catch using sophisticated fishing equipment such as beach seine (*Dala*). Discussions additionally revealed the following as causes of declining fish catch: Use of beach seine (*Dala*) which catches eggs and juvenile fish and prevent the growth of smaller fish, Menace of storms, and water hyacinth which causes tearing of fishing nets, Cutting of Niger grass by fishermen in order to catch all fish species that inhabit the particular surrounding water body, High wind turbulence caused by massive cutting of Niger grass which displaces fishing nets, Use of fish fencing (*dumba*) which catches small-sizes of fish. This is made from rows of trap with nylon net of fine mesh with size of about 1 inch (25mm) and arranged in rows of several kilometers to form barrier to fish passages. The total declining yield estimates reported by Erinne (1989) are shown on table 24.Furthermore, 68.8% of the respondents indicated that there are certain fish species that disappeared from the waters of Yauri after Kainji dam construction.

Table 2: ***Distribution of Fishermen Based on Estimated Fish Catch per Unit Effort n= (460)***

Fish Catch Per Unit Effort (kg)	Before the Dam	After the Dam
Less than 2	30(6.5)*	190(41.3)
2-4	21(4.6)	18(3.9)
4.1 – 6	23(5.0)	24(5.2)
6.1 – 8	185(40.2)	203(44.1)
More than 8	201(43.7)	25(5.4)
Total	**460(100)**	**460(100)**

* Figures in parentheses are percentages Source: Field Survey, 2023

CONCLUSION

The research work was carried out on the effect of artisanal fisheries on livelihood of the fishing communities along Kainji dam, Nigeria. From local to global levels, artisanal fisheries play important roles in food supply, income generation and nutrition. Encapsulating appropriate instruments that may enhance artisanal fish catch levels is one of the most intractable challenges in developing countries, Nigeria inclusive. The outcome of this study shows that fishers do not receive adequate extension services which should have exposed them to better fishing techniques. To conclude, the research showed that, fishing activity is important in the lives of the fishers along the two dams. The constraints that faced the industry such as high cost of fishing gears, lack of credit facilities, lack of modern technology, poor storage facilities, inadequate extension services, shortage of manpower and lack of government incentives hinder full realization of the potentials of the artisanal fishing industry

Based on the effect of artisanal fisheries on livelihood of fishers, findings indicated that artisanal fishing had an effect on the livelihood of the fishers because it is a viable and profitable enterprise capable of providing employment opportunities in the rural communities. Government organs responsible for fishery development should promote the development of both artisanal and aquaculture so as to meet the fish demand supply deficit in Nigeria.

Fisheries extension agents should advise fishers to properly use their wealth of experience in fishing to drive home more fish landings. This could be achieved through the use of fisheries membership association, accessing credit facilities and costing all the resource inputs used in the fishing activities including fishing gears used with the view to genuinely assess the economic worth of fishing enterprises.

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ASSESSMENTS OF CONSTRAINTS FACED BY ARTISANAL FISHERS IN YAURI EMIRATE, KEBBI STATE, NIGERIA.

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ABSTRACT
The study was designed to assess the constraints faced by artisan fishermen in Yauri Emirate, Kebbi State, Nigeria. Ninety (90) artisan fishermen were selected using two-stage sampling techniques. Questionnaire and interview schedule were used to obtain information from the respondents. The data obtained were analyzed using frequency distribution tables, percentages and mean. On the socio-economics characteristics of the artisan fishermen, it was found that the majority (58%) of the respondents were male; 36% of the respondents were having secondary school Education as their highest level of education. Also,31% have fishing experience of below 10 years with yearly fish output of above 1000kg and yearly income of greater than ₦200,000.00. While 81% belong to one form of co-operative society or the other. Extension agents have visited none of the respondents. The constraints faced by artisan fishermen were seasonal changes in the volume of water, inadequate finance, and poor sales. Based on the findings of the study, it was recommended that, the government and other appropriate authorities should enforce the fishing laws and regulations to avoid illegal exploitation of fishing grounds and ensure the sustainability of artisan fishing by making extension services available to fishers in the Emirate.
Keywords: *Assessment, Artisan fishermen, constraints, Yauri Emirate.*

INTRODUCTION
The existence of enormous water bodies offers great potentials for the development of the fishing industry in Nigeria. Fisheries development began in 1914 in Nigeria when the first fisheries office was established as a component of the Agricultural office of the colonial administration (Anko & Eyo, 2003). Artisanal fishery subsector accounts for over 80% of total fish output in Nigeria as evidenced by available data from the Federal Department of Fisheries. An artisanal, traditional or small scale fishery is used to characterize those fisheries that were mainly non-fishery in tropical developing countries (Berkes,*et al* 2007). Ekpo and Essien-Ibok (2013) noted that artisanal fishing is a major producer of fish for the teaming population of Kebbi State and Nigeria at large though in the recent times, there has been a significant drop in the quantity of fish catch in the area. Generally, artisanal fishing operation is tedious and characterized by low individual productivity. The problems faced by artisanal fishers in Nigeria are not far from what is experienced by artisanal fishers in Yauri Emirate. Some of the problems faced by artisanal fish farmers in Yauri Emirate include lack of enforcement of fishing regulation, changes in the volume of water and climatic factors, the use obnoxious means in fishing, poor mesh size regulation (the use of wrong type of fishing gear by trawlers and fishers) and continuous increase in the price of fishing gears (Anko & Eyo, 2003). This research was designed to assess the socio-economic characteristics and constraints faced by artisanal fishers in Yauri Emirate.

METHODOLOGY
Study Area
Yauri is an emirate in Nigeria's occupying the Yauri Local Government Area. Kebbi State, it is located at latitude 10^0 44' 33.59" N and Longitude 4^0 46' 23.99" E, it is one of the smallest historical emirates in Northern Nigeria. In 1972, the population was about 112,000 people inhabiting a land area of about 1,306 square miles (3,380 km^2) and scattered over six major districts. The area was first settled by an eastern group around early 1000-1200 AD. Farming is the major occupation of early settlers because of the fertile land and gradually fishing because of the river (Salamone 1980).

Data Collection and Analysis

Ninety (90) artisanal fishers were selected using two-stage sampling techniques. Questionnaire and interview schedule were used to obtain information from the respondents. The data were analyzed using percentages, mean and regression analysis.

RESULTS AND DISCUSSION

Socio-economic Characteristics of the Fishers

Table 1 showed the socio-economic characteristics of artisanal fishers in the study area. The majority (58%) of the respondents were male. This is an indication that males were more in artisanal fishing in the study area. This agrees with the findings of Okeowo, *et al* (2014) which revealed that males dominate artisanal fishing. The table further showed that 76% of the artisanal fishers were 50 years and below. This is an indication that majority of the proportion of the artisanal fishers in the study area are still in their active age. This agrees with the findings of Shettima *et al* (2014), which indicated that most of the fishers were in their youthful age. The table also reveals that the majority (73%) of the artisanal fishers were married. This indicates that many of them are saddled with family responsibilities and as such have the tendency of abandoning fishing if there is no enough financial proceed to take care of their family. This also agrees with the findings of Okeowo *et al.* (2014) who revealed that majority of the respondents in Epe and Badagry were married. Only 27% did not have any formal education, the remaining 73% had primary, secondary or tertiary education. The majority of the artisanal fishers are literate enough to adopt new technologies that can improve their fishing activities since education is known to increase fisherman's tendency to adopt new technologies. (58%) majority of artisanal fishers have household size of 5 persons and above. They maintain moderate number of persons in the households. The table revealed that 69% have fishing experience of over 10 years and had stayed long enough in the enterprise to have acquired the necessary knowledge and skill involved in the fishing enterprise. Only 9% of the artisanal fishers have yearly fish output of 400kg and below. The rest have more than 400kg. Only few proportion (31%) produce above 100kg. this shows that the majority of the fishers don't produce substantial quantity. (53%) a good number of fishers earn N200, 000 and above on yearly basis. This is an indication that many of them are still living below the poverty index. It was also shown in Table 1 that 81% of the artisanal fishers are members of co-operative society. This indicates that a cordial relationship exists amongst the fishers and as such extension services if and when available would be easy. All (100%) of artisanal fishers agreed that no extension agent has ever visited them. This is surprising as agricultural extension agent are supposed to extend their services to these group of fishers.

Table 1: Percentage Distribution of Yauri Emirate fishers according to socio-economic characteristics

Variable	Percentage (n=100)
Gender	
Male	58
Female	42
Age	
Below 20	18
21 – 30	12
31 – 40	23
41 – 50	23
Above 50	24
Marital status	
Single	27
Married	73
Highest level of education	
No formal education	27
Primary	24
Secondary	36
Tertiary	13
Household size	
Below 5	42
6 – 10	41
11 – 15	15
16 – 20	1

Above 20	1
Fishing output	
0 – 400	9
401 – 600	17
601 – 800	18
801 – 1000	25
Above 1000	31
Yearly income	
Less than N50,000	3
Equal to or more than N100,000	18
Equal to or more greater than N150,000	22
N200,000 and above	57
Co-operative membership	81
Visit from extension agents	0

Source: Field survey, 2023

Constraints faced by artisanal fishers in Yauri Emirate

Table 2 showed the constraints faced by artisanal fishers in Yauri Emirate, Kebbi State. It showed that out of the thirteen variables used to capture the constraints artisanal fishers faced in the fishing activities; only four were not seriously affecting the fishers namely; religious barriers, increased on fisheries resources, lack of extension services and unfavorable union activities and levies. The fishers do not even know what extension services are all about as they have never seen any extension agent around and such do not appreciate the need and use of extension information to improve their fishing activities. Other factors including conflict amongst fishers, type of instrument used, shortage of man power, inadequate finance, poor storage facilities, poor sales, and high cost of instruments were some of the constraints found to be affecting the fishers in the seriously in the study area. Shettima *et al.*, (2014) revealed that 24% of the respondents were constrained by breeze (wind), 14% of the fishers indicated unavailability of fish during windy periods and when there is high water volume as the constraint they faced in the study area. It was ranked second most important constraint by the respondents. The other constraints faced by the fishers in the study area were unavailability of fishing equipment (20%), lack of formal education (15%) and insufficient fund (18%) ranked fourth, fifth and sixth respectively.

Table 2: Constraints faced by artisanal fishers in Yauri Emirate

S/N	Factors	Standard deviation	Mean
1.	Religious barriers	0.00	1.0
2.	Conflict amongst farmers	1.17	3.4*
3.	Use of crude tools	0.00	5.0*
4.	Type of instrument	0.99	3.2*
5.	Shortage of man-power	0.94	3.1*
6.	Increased pressure on fisheries resources	1.06	2.0
7.	Inadequate finance	0.77	4.6*
8.	Poor storage facilities	1.10	3.9*
9.	Poor sales	0.72	4.4*
10.	Lack of extension services	0.68	1.7
11.	Aquatic grasses	0.00	5.0*
12.	Unfavorable union activities and levies	1.23	2.9
13.	High cost of instruments	1.05	3.8*

Source: Field survey, 2023.

Relationship between artisanal fishers' socio-economic characteristics and constraints

Table 3 showed the result from ordinary least square regression analysis to determine the relationship between the artisanal fishers' socio-economic characteristics and the constraints faced. The linear functional form was chosen as the lead equation based on the high value of R^2, number of significant coefficients, appropriateness of signs and highest F-value, ($F=10.51$; $P\leq0.5$). The coefficient of multiple determination (R^2) value of 0.58 indicates that about 58% of the variation in the constraints faced in artisanal fishing could be explanatory variables while the remaining 42% was due to other factors not specified in the model. The coefficient of age (x_2) correlation positively and significantly with the constraints faced in artisanal fishing. This could imply that older fishers face more constraints in their fishing activities than the younger ones. This may not be surprising as older fishers who have passed their productive age are known to be physically weaker than younger ones and may find it more difficult to face the challenges in fishing activities. Educational attainment (x_4) and fishing experience (x_6) were negative and significant at 5% significant level. More educated fishers are known to possess more skills and knowledge to tackle challenges, adopt new technologies and adapt to changing environment. Also, fishers who have spent more number of years in fishing activities are known to have gathered more skills and knowledge to tackle challenges and constraints more vigorously than ones with less experience. Furthermore, yearly income of the fishers was negatively significant at 10% probability improved practices that could lessen the constraints and challenges faced in their fishing activities.

Table 3: Relationship between artisanal fishers's socio-economic characteristics and the constraints faced.

Variable	Linear	Semi-log	Exponential	Double long
Constant	42.709	41.702	3.732	3.725
	(19.277)***	(24.610)***	(24.197) ***	(19.078) ***
Gender (X_1)	0.584	0.649	0.009	0.018
	0.308	1.802	0.12	0.038
Marital status (X3)	0.440	0.374	0.10	0.009
	(0.301)	(0.312)	(1.082)	(0.340)
Educational attainment (X4)	-1.412	-0.997	-0.006	-0.021
Household size (x5)	0.296	0.563	0.007	0.012
Fishing experience (x6)	-3.31	-1.554	-0.020	-0.032
	(-2.131)**	(-1.266)	(-1.069)	(01.133)
Fish output (x7)	0.632	2.649	0.014	0.057
	(1.227)	(1.227)	(1.069)	(1.143)
Income (x8)	-2.560	-1.880	-0.012	-0.38
	(-1.926)	(-0.929)	(-0.829)	(-0.815)
R2	0.58	0.289	0.354	0.295
F-statistic (F-value)	10.51	7.10	9.561	6.412

Source: Field Survey, 2023

***P≤0.1, **P≤0.5. The values in parenthesis are t-values.

CONCLUSION AND RECOMMENDATION

The constraints faced by fishers in Yauri Emirate, Kebbi State are Fluctuation in the volume of water, inadequate finance, Lack of extension services, poor storage facilities, poor sales, and high cost of instruments. These constraints need to be addressed to improve productivity of artisanal fishers in Yauri Emirate. It is recommended to enforce fishing laws and regulations to avoid illegal exploitation of fishing grounds, mesh size regulation, access to fund to improved their fishing equipment or instrument and access to information through extension serves in Yauri and other parts of Kebbi state and beyond.

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GROWTH PERFORMANCE AND SURVIVAL RATE OF *HETEROBRANCHUS BIDORSALIS* FRY FED ON LIVE FEED ZOOPLANKTON (*MOINA MICRURA*) AND PROCESSED FEED (ARTEMIA AND COPPENS)

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ABSTRACT
African catfish (Heterobranchus bidorsalis) is cultured as food fish and is also used to control overpopulation in tilapia ponds. High demand for catfish fingerlings has resulted in many farmers venturing into the fingerling production business. In this study, the performance of three different feeds: live zooplankton (Moina micrura), Artemia and coppens on the growth performance of H. bidorsalis fry, were assessed. H. bidorlis fry were raised in 9 plastic tanks for a period of 16 days. M. micrura was in a mono specific state and were harvested washed clean from algae and fed to fish. Feeding was done for five days to satisfaction with the treatments (Artemia, Coppens and live M. micrura). Data analyzed showed that there was significant difference (p<0.05) in all the growth parameters assessed. Result of the study further revealed that percentage mean weight gain, specific growth rate, increase in length and condition factor were highest (116.45%, 4.83, 2594.4% and 5.28) in fry fed live zooplankton (M. micrura) whereas survival rate was not significantly different between LPZF1 and LPZF2 respectively. Water quality parameters monitored were within the acceptable range (temperature; 27-30°C, dissolved oxygen; >3mg/L, pH; 7.3-8.5 etc) for fry production. Commercial fish farmers practicing H. bidorsalis fry culture are recommended to raise their larvae on live M. micrura as starter feeds for the purpose of enhancing faster growth performance.
Keywords: *Heterobranchus bidorsalis, Moina micrura, Artemia and coppens*

INTRODUCTION
Many fish larvae require live food at the onset of exogenous feeding. Nutrient assimilation studies in fish larvae at the onset of exogenous feeding are limited by a number of factors. The composition of artificial diets can be modified easily but their acceptance by the larvae is often low (Schlechtriem, *et al*., 2004). When fishes raised in semi-intensive ponds are supplemented with low protein feeds, dietary protein is largely provided by the natural food. Hepher (1988) and Schroeder *et al*. (1990) reported that natural food contributed between 300 and 500 g/kg of growth when tilapia was supplemented with artificial feeds in fertilized ponds. The protein content of natural food ranges between 550 and 700 g /kg on a dry matter basis (Hepher, 1988). For many fish species, the larval period is considered critical in their life history. Success of larval rearing depends mainly on the availability of suitable diets that are readily consumed, efficiently digested and that provide the required nutrients to support good growth and health (Giri, *et al*., 2002). Larvae, especially first-feeding larvae, generally depend on live food. While live food is difficult to sustain and requires considerable space and expense, micro diets are easier to maintain and usually have lower production costs (Jones *et al*., 1993, Person-Le Ruyet *et al*., 1993). The development of formulated diets allows for production of valuable fish larvae without using live prey. The possibility of replacing live feed with manufactured diets from the onset of exogenous feeding has been investigated in several studies (Jones *et al*., 1993, Person-Le Ruyet *et al*., 1993). Limited success has been achieved in first feeding larvae with the complete replacement of live feeds. In freshwater zooplankton, cladocerans are important because many of them are voracious predators, feeding on algae, ciliates, rotifers, larval insects, and small cladocerans (Monakov 2003), thereby structuring plankton communities.
Several cladoceranss, are facultative predators and grow better on animal diets (Williamson and Reid, 2001). Wang *et al*. (2005) found that the survival was significantly higher in larvae fed live food than in larvae fed the three formulated diets. Introduction of live zooplankton is therefore being investigated as an alternate to pond

fertilization for increasing fish yields while avoiding water quality deterioration, (Jha, *et al*., 2007). A variety of environmental factors are known to affect zooplankton production. Recent research has focused on the relative importance of food quantity and quality. Among zooplankton, brine shrimp (*Artemia spp*) and moina (*Moina micrura*) have been used most extensively as a live food for rearing of marine and freshwater fishes (Bengtson *et al*., 1991). The use of *Artemia nauplii* is well established due to its many advantages: year-round availability as on the shelf cysts; good nutritional value for some fish; and relatively easy improvement through simple enrichment techniques (Leger *et al*., 1986). Aquaculture production of *Heterobranchus bidorsalis* has been practiced for a long time in Africa. Increased productivity of fry and fingerlings with attributes of faster growth rates and better environmental tolerance, and ensuring fish food security in Africa. *Heterobranchus* exhibits many qualities that make it suitable as aquaculture candidate. These include ability to withstand stress, disease resistant, fast growth rate, high yield potentials, high fecundity and good taste among others. They can also withstand low dissolved oxygen (D.O.) and pH level and grow on turbid water. Growth and survival data are powerful tools for understanding the effects of both live and manufactured diets on first-feeding fish larvae (Wang *et al*., 2005). The present study was conducted to evaluate the growth performance and survival rate of *H. bidorsalis* fed live zooplankton and processed feeds.

MATERIALS AND METHODS

Procurement of Experimental Fish.

Heterobranchus bidorsalis broodstocks were sourced from a reputable fish farm and they were acclimatized for a period of seven days, during which they were fed four times daily. The broodstocks were used for breeding to obtain the fry that was used for the study. Nine hundred (900) *Heterobranchus bidorsalis* fry was used for the study.

Collection, Identification and culture of *Moina micrura*

Moina micrura was collected from the Department of Aquaculture and Fisheries Management fish farm of the Faculty of Agriculture, Nasarawa State University Keffi, Shabu- Lafia Campus. Lafia is located on latitude 8° 35'N, longitude 8° 32'E, altitude 181.53m above sea level with a mean temperature of 34°C, relative humidity of 40-86% and average day light of 9-12h (NIMET, 2011).

Moina micrura was cultured in mono-specific state on filterate of manure according to the method Okunsebor (2014) for 14 days. Plankton net was used to harvest the *Moina micrura* to feed the fry four (4) times daily to satiation. The *Moina micrura* were collected and used for the feeding of the fry after they were washed clean from algae.

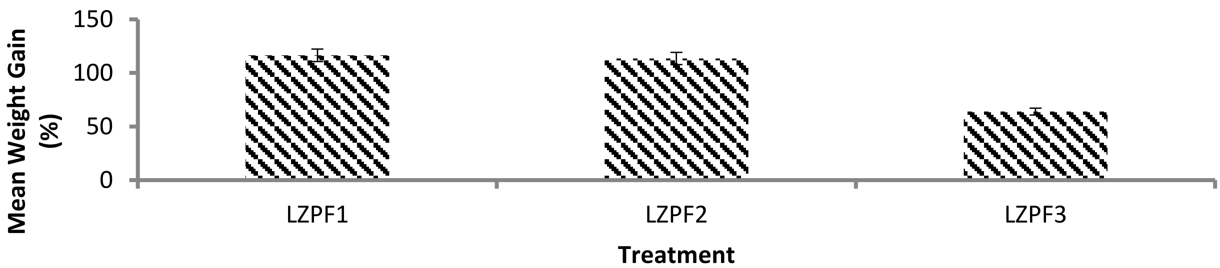
Experimental Procedure

The experiment was carried out in three treatments and three replicates comprising of: live *Moina micrura*, processed artemia and coppens for the period of 16 days. The fry were selected at random from the acclimatized population and stocked at 100 fry per 30 litres of borehole water in a rearing bowl. Water was changed regularly after four days and aerator was used to maintain dissolved oxygen required. Water quality parameters (pH, dissolved oxygen, temperature, carbon dioxide etc) were monitored using water testing kits.

Statistical Analysis

Data collected in this experiment was analysed using Analyses of variance (ANOVA) and significant mean was separated at 0.05 probability level as described by (Steel *et al*., 1997).

Results and Discussion

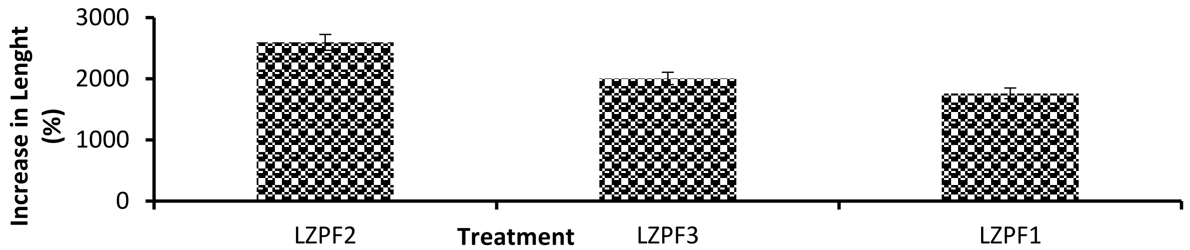


LZPF1 = *Moina micrura* LZPF2 =Coppens LZPF3 = Artemia

Figure 1: Mean weight gain of *H. bidorsalis* fry fed on live *Moina micrura* and processed feeds (artemia and coppens)

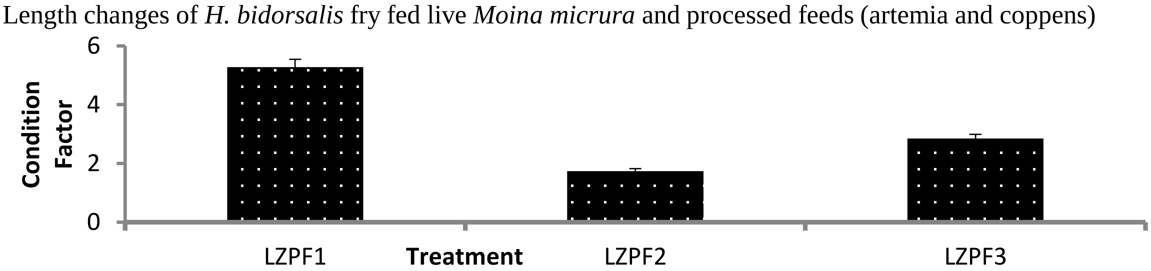
LZPF1 = *Moina micrura* LZPF2 =Coppens LZPF3 = Artemia

Figure 2: Specific growth rate of *H. bidorsalis* fry fed on live *Moina micrura* and processed feeds (artemia and coppens)



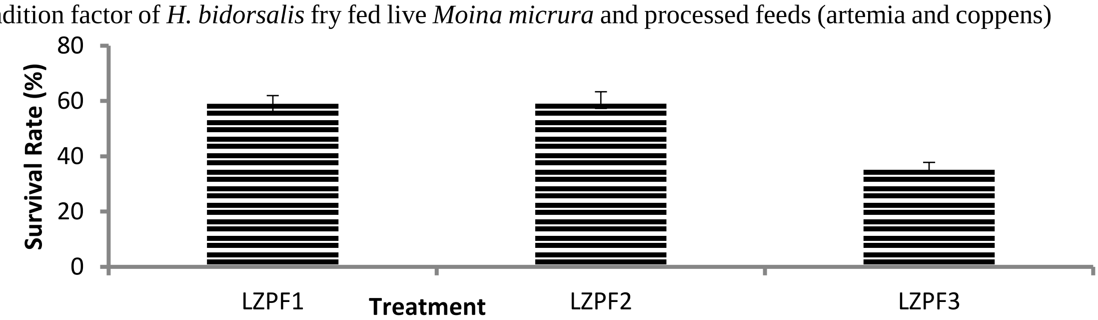
LZPF1 = *Moina micrura* LZPF2 =Coppens LZPF3 = Artemia

Figure 3: Length changes of *H. bidorsalis* fry fed live *Moina micrura* and processed feeds (artemia and coppens)



LZPF1 = *Moina micrura* LZPF2 =Coppens LZPF3 = Artemia

Figure 4: Condition factor of *H. bidorsalis* fry fed live *Moina micrura* and processed feeds (artemia and coppens)



LZPF1 = *Moina micrura* LZPF2 =Coppens LZPF3 = Artemia

Figure 5: Survival rate of *H. bidorsalis* fry fed live *Moina micrura* and processed feeds (artemia and coppens)

Growth of the *Heterobranchus bidorsalis* fry was significantly affected by different diets. Fry fed on *Moina micrura* showed superior growth over those fed on artemia and coppens. This results agrees with the findings of Lim *et al*. (2002) and Paulet (2003) for larval of goldfish, *Carassius auratus*. These workers found that the larvae fish grew best on live zooplankton than other first feed used in larvae culture. Adeyemo *et al*. (1994) similarly reported that *Heterobranchus bidorsalis* and *Clarias gariepinus* grew better when fed with *Moina dubia* (a freshwater zooplankton) than when fed with *Artemia nauplii*. On the contrary, Hung *et al*. (1999) reported that larvae of Mekong catfish, *Pangasius bocourti* exhibited lower growth performance when fed with *Moina sp*. compared with *Artemia nauplii*. Also, Kerdchuen and Legendre (1994) reported a better growth performance of *Heterobranchus longifilis* fed with *Artemia nauplii* than *Moina sp*. The poor growth of African catfish larvae fed artificial diet had also been reported for other catfishes: *Heterobranchus longifilis* (Kerdchuen and Legendre, (1994), *Clarias gariepinus* (Adewolu and Ossai 2001), Mekong catfish, *P. bocorti* (Hung *et al*., 1999) and *Chrysicthys nigrodigitatus* (Adewolu, 1998).

The reason for the poor growth may be related to the texture of the dry feed, its digestibility and nutrient leach in water. In addition, may also be related to lack of functional stomach, particularly the absence of proteolytic enzymes during the first few days of exogenous feeding (Kerdchuen and Legendre, 1994; Mills *et al*. (1996). Dabrowski (1982) reported that many fish fry do not have enzymes for digesting artificial diets and digestion in these fish larvae is carried out by enzymes present in their live diets.

The specific growth rate obtained in this study was between 3.09 – 4.83. This result is very close to the maximum average SGR values (4.07 – 4.19) calculated in *Clarias gariepinus* after a 10-day feeding period with decapsulated cysts of *Artemia* (Verreth and Den Bieman, 1987) and suggests that *H. longijïlis* and *C. gariepinus* fry have a similar growth potential. Significant differences were found among treatments in total length (TL) over the culture period. Fish growth for the culture duration appears to have been influenced by the type of diet. The growth in length of fry in this study was considered to be significantly higher than what has been reported in the literature. Verreth *et al*. (1993) reared *Clarias gariepinus* larvae for 10 days on decapsulated Artemia cysts. They obtained a mean TL of (15.954 ± 1.021 mm) after 10 days.

Condition factor of fry fed live zooplankton (*Moina micrura*) was above 3.0 which is an indication that the fish have better well-being compared to fry fed artemia and coppens with condition factors below 3.0. Condition factors value from 3 and above indicates a robust fish while values below 3 indicates a lean fish (Le Cren, 1951). In this work, it was observed that survival rate of fry fed with Artemia and coppens were similar and higher than survival rate of fry fed live zooplankton (*Moina micrura*). The lower survival rate recorded in fry fed *Moina micrura* could not be attributed to diet composition but could be as a result of differential growth which causes cannibalism among the fish in the treatment (Nyina-Wamwiza *et al.,* 2007).

CONCLUSION AND RECOMMENDATIONS

In conclusion, this study has shown the superiority of live *Moina micrura* over Artemia and Coppens, as live food for the *Heterobranchus bidorsalis* fry. Fry fed with live *Moina micrura* had better growth survival rate and increase in length compared to fry fed artemia and coppens.

Artemia and Coppens are imported and may be expensive for an average fish farmer, therefore *Moina micrura* may be a better alternative to them as this zooplankton is locally available in most freshwaters in Africa. Commercial fish farming practicing *Heterobranchus bidorsalis* fry culture are recommended to raise their larvae on live *Moina micrura* as starter feeds for the purpose of enhancing faster growth performance. Environmental conditions along with water parameters should be monitored and checked when breeding African catfish like other fish species for higher survival rates and higher growth performances.

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GROWTH PERFORMANCE, NUTRIENT UTILIZATION AND CARCASS COMPOSITION OF AFRICAN CATFISH JUVENILES FED WITH PROCESSED *CITRULLUS LANATUS* (WATERMELON) SEED MEAL-BASED DIET

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ABSTRACT
The study was conducted on growth performance, nutrient utilization and carcass composition of African catfish juveniles fed with processed watermelon seed meal-based diet. Four (4) treatments in three replicates were stocked with 30 juveniles of Clarias gariepinus under flow through system and were fed supplemented watermelon seed meal diet at 0%, 25%, 50% and 75%. Feeding was done 8:00am in the morning and 7:00pm in the evening at 3% body weight/day for 70 days and was adjusted fortnightly at new weight. Water quality parameters was monitored and maintained. The result revealed that mean weight gain (11.98±0.00) percentage mean weight gain (91.24±0.00), specific growth rate (0.17±0.00), and feed intake (592.05±36.64) were significantly higher in treatment fed T2 (25% watermelon seed meal inclusion) whereas feed conversion ratio (2.90±0.000) and survival rate (90.00±0.00) were significantly higher in T1 (0% watermelon seed meal inclusion). The use of watermelon seed meal as supplementary feed for C. gariepinus juveniles is highly recommended at 25% inclusion.

Keywords: *Watermelon seed, Carcass Composition and Clarias gariepinus*

INTRODUCTION
Aquaculture production is becoming more and more intensive; this is because production from capture fisheries has reached its maximum possible potential, as the catch is dwindling with each passing day (Gabriel *et al*., 2007). Jamiu and Ayinla (2003) had stated that feed management determines the viability of aquaculture as it accounts for at least 60 percent of the cost of fish production (Akinrotimi *et al*., 2007), therefore the establishment of economically viable fish culture ventures requires the incorporation of agricultural wastes or by-products as feed ingredients or direct feed (Shang and Costa-Pierce, 1983) to replace conventional feed stuffs whose dwindling supply has resulted into arbitrary hike in prices. Conventional ingredients used in fish feed are in high demand for human consumption and their yields are currently insufficient to match their demands, hence out of concern for and the implications for food security as well as water and land use, there is urgent need to get local materials especially agricultural by-products of lower price to replace these costly feed materials.
Watermelon (*Citrullus lanatus*) seed meal (WMSM) is one of such agricultural by-product whose nutritive potential has not been effectively taped in animal nutrition, especially fish. Watermelon a creeping annual cash crop which belongs to the family Curcurbitaceae. It grows successfully in the tropics and sub tropics (Mohr, 1989). Watermelon seed is rich in minerals, protein, vitamins, carbohydrate and fibre (Duke and Ayensu, 1985; Tarek and Khaled, 2001). Watermelon seeds are rich in oil and protein (Mustafa *et al*., 1972; Alkhalifa, 1996). Watermelon seed oil proved to be good source of high quality edible oil characterized by low free fatty acid content (Mustafa *et al*., 1972). The experience with watermelon seed cake or meal in rations for animals, showed that it is a good source of digestible protein comparable to other oil seed cakes like cottonseed, linseed etc hence can be safely incorporated in animal feeds (Singh *et al*., 1973). In view of the increasing demand for fish and high cost of conventional feed ingredients, it is therefore necessary to investigate the appropriate method of processing water melon seed for better utilization by *C. gariepinus* juveniles. The main objective of the study is to determine the growth performance and survival rate of *Clarias gariepinus* fed with processed *Citrullus lanatus* seed meal.

MATERIALS AND METHODS

Experimental Site

The study was conducted at the Department of Aquaculture and Fisheries Experimental Farm, Faculty of Agriculture, Nasarawa State University Shabu-Lafia Campus. Lafia is located on latitude 8° 35' N and longitude 8° 32' E, altitude 181.53 m above sea level NIMET (2011).

Procurement and Acclimatization of Experimental Fish

A total of One Hundred and Twenty (120) *Clarias gariepinus* juveniles were obtained from a recognized fish farm. The experimental fish were acclimatized for a period of 7days under experimental conditions in an outdoor concrete tank of the Departmental Fish Farm.

Experimental Design

The source of water for the experiment was from the experimental farm borehole, four (4) concrete tanks of 1.5x1x1.5m³ were filled with water uniformly and 30 *Clarias gariepinus* juveniles were randomly stocked in each pond. The design of the experiment was completely randomized design. The experiment consisted of four (4) treatments which are sun drying alone, fermentation and boiling and the control diet that does not contain WMSM. The fish were starved for twenty four (24hrs) to maintain uniform stomach condition and to induce their appetite prior to the use of experimental diets. The fish were randomly distributed into four (4) concrete tanks in three replicates. The fish were assigned randomly to each tank, and they were fed with the formulated feed for ten (10) weeks. They were fed 3% of their body weight for 70 days. During the experimental period, water quality parameters (Dissolved oxygen, pH, Temperature, Carbon dioxide and Ammonia) were kept within acceptable range for fish culture.

Proximate analysis of fed

The proximate analysis of the experimental feeds were also carried out for Crude protein content, ash content, lipid/ether extract, nitrogen free extract (NFE), and moisture content following the standard by AOAC (1990).

Carcass Analysis

At the end of 10 weeks, one fish per treatment and replicate was selected at random and starved for about 18 hours to empty their Gastro-intestinal tracts. They were sundried and grinded into fine powder and packaged into separate polythene bags. The carcasses were analyzed at the laboratory of Animal Science, Faculty of Agriculture, Nasarawa State University Keffi, Shabu-Lafia Campus.

Statistical analysis

Data obtained were analyzed using one way Analysis of variance (ANOVA) and significant mean differences were separated at 0.05 probability level as described by Steel *et al*. (1997).

RESULTS AND DISCUSSION

Proximate composition of experimental diets is presented in Table 1 below. The result revealed moisture content of the diets ranges from 5.00% to 5.37% with T3 having the highest moisture content of 5.37%. Crude protein contents of the diets ranges from 40.00% to 40.89% with T1 having the highest crude protein value. Lipid (Ether extract) value of the diets was from 7.15% to 9.69%. The highest lipid value of 9.69% was obtained in T4 followed by 9.62% in T3. Crude fibre content of the feeds ranges from 5.19% to 6.41% with T1having the lowest crude fibre content and T2 having the highest value of 6.41%. Ash content of the feeds ranges from 7.14% to 8.19% respectively. T1 had the highest ash content value of 8.19% followed by T4 with 7.92% and T3 with 7.53% while the lowest as content value of 7.14 was obtained in T2. Nitrogen free extract content of the feed in this study ranges from 30.98 to 33.58 with T1 having the Highest NFE value of 33.58% followed by T2 with 32.68% and T3 with 31.23% while the least value 30.98% was obtained in T4.

Table 1: Proximate composition of experimental diets

Parameters	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)
Moisture (%)	5.00	5.00	5.37	5.00
Crude protein (%)	40.89	40.47	40.00	40.13
Lipid (%)	7.15	8.30	9.62	9.69
Crude fibre (%)	5.19	6.41	6.26	6.28
Ash (%)	8.19	7.14	7.52	7.92
NFE (%)	33.58	32.68	31.23	30.98

Mean weight gain of Clarias gariepinus juvenile fed watermelon seed meal is shown in Table 2. Result from Anova table shows that the treatments were significantly different ($p<0.05$) from each other. Fish feed T2 (25% watermelon seed meal inclusion) had the mean weight gain of 11.98+0.00 followed by fish feed T1 (0% inclusion) with 11.57+0.00. The lowest mean weight gain of 9.07+0.00 was recorded in T3 (50% inclusion). Percentage mean weight gain (%) of *Clarias gariepinus* juvenile fed watermelon seed meal presented in Table 3 revealed that the highest percentage mean weight gain 91.24+0.00 was obtained in fish fed T2 (25% inclusion), followed by

T1 (0% inclusion) and T3 (68.71+0.00) while the lowest percentage mean weight gain 44.92+0.00 was obtained in fish fed T4 (75% watermelon seed inclusion). The results showed that there was significant difference ($p<0.05$) in percentage mean weight gain among the treatments.

Table 2: Growth performance of *Clarias gariepinus* juveniles fed with differently processed watermelon seed meal based-diet

Parameters	T1	T2	T3	T4
Initial weight (g)	132.6	131.3	132.0	132.3
Final weight (g)	248.3	251.0	222.7	240.2
Mean weight gain (g)	11.57±0.00^{b}	11.98±0.00^{a}	9.07±0.00^{d}	10.79±0.00^{c}
Percentage mean weight gain (%)	87.25±0.00^{b}	91.24±0.00^{a}	68.71±0.00^{c}	44.92±0.00^{d}
Specific growth rate	0.16±0.00^{b}	0.17±0.00^{a}	0.13±0.00^{c}	0.16±0.00^{b}
Feed conversion ratio	2.90±0.00^{a}	2.85±0.00^{b}	2.82±0.00^{c}	2.67±0.00^{d}
Feed intake (g)	523.84±31.06^{b}	529.05±34.64^{a}	404.10±20.17^{d}	432.66±42.29^{c}
Protein efficiency ratio	0.54±0.02^{d}	0.55±0.04^{c}	0.56±0.03^{b}	0.62±0.05^{a}
Survival rate (%)	90.00±0.00^{a}	86.67±0.05^{b}	76.67±0.05^{d}	83.33±0.15^{c}

Mean with different superscript along the row are significantly different

Specific growth rate (SGR (%) of *C. gariepinus* juvenile watermelon seed meal is shown in Table 2. The highest specific growth rate (0.17+0.00) was recorded in T2 and it was significantly different ($P<0.05$) from other treatments. T1 and T4 (0 and 75%) were not significantly different ($p>0.05$) from each other. Feed conversion ratio of *C. gariepinus* juveniles fed watermelon seed meal is shown in Table 3. Results from the ANOVA shows that the treatments were highly significant from each other. T1 (0% watermelon seed meal) had the highest 2.90+0.00 feed conversion ratio and it is significantly different ($P<0.05$) from the treatment. T4 had the lowest feed conversion ratio 2.67+0.00. Feed intake results as presented in Table 3 below showed that feed intake among the treatments were significantly different ($p<0.05$). Highest feed intake value 529.05+34.65 was obtained in fish fed T2 (25% watermelon seed meal inclusion) followed by 523.84+31.06 in fish fed T1 (0% inclusion), 432.66+42.29 in fish fed T4 (75% inclusion) while the least feed intake value of 404.10+20.17 was obtained in T3 (50% inclusion of watermelon seed meal).

Protein efficiency ratio of *C. gariepinus* juvenile fed watermelon seed meal is shown in Table 3. Results from the ANOVA table shows that the treatment were significantly different ($p<0.05$) from each other. T4 had the highest protein efficiency ratio (0.62+0.05) and it is significantly different ($p<0.05$) from other treatments followed by T3 with 0.56+0.03 and T2 with 0.55+0.04. The lowest protein efficiency ratio 0.54+0.02 was obtained in T1. Survival rate of *C. gariepinus* juvenile fed watermelon seed meal is shown in Table 2. Result from the ANOVA shows that the treatments were not significantly different from each other. T1 had the highest survival rate of 90% followed by T2 with 86.67% and T4 with 83.33% while the lowest survival rate 76.67% was obtained in T3 respectively.

Proximate composition of carcass of *C. gariepinus* juveniles fed differently processed watermelon seed meal is presented in Table 3. The result showed that carcass values were higher than the initial values recorded. The crude protein content values increase ranges from 15.15 – 15.71% as compared with the initial 13.44%. Diet 1 had the highest crude protein value of 15.71% while diet 4 had the lowest crude protein value of 15.13 but were higher than the initial. Crude fat content of the diets increases from 6.55 – 8.66% compared with the initial 6.22%. The highest crude fat value of 8.66% was obtained in T2 followed by 7.70% in T4.

Table 3: Carcass composition of *Clarias gariepinus* juveniles fed differently processed watermelon seed based-diet.

Parameters	Initial	T1	T2	T3	T4
Crude protein (%)	13.44	15.71	15.41	15.09	15.13
Fat (%)	6.22	7.20	8.66	6.55	7.70
Crude fibre (%)	1.63	1.87	2.00	1.60	2.10
Ash (%)	1.89	2.00	2.02	2.79	2.14
NFE (%)	22.69	9.10	7.64	10.99	10.71
Moisture (%)	54.13	64.12	64.27	62.98	62.22

Crude fibre content values of the fish carcass ranges from 1.60 – 2.10%. The crude fibre content values in this study increases as compared with the initial but the initial crude fibre content was higher than that recorded for T3. Ash content of the carcass ranges from 2.00 -2.79% and were higher than the initial value. Nitrogen Free

Extract values of the carcass ranges from 7.64 – 9.10 and were lower compared to 22.69% recorded for the initial value while moisture content was also higher from 62.22 – 64.27% compared with 54.13% initial value. The result of this study indicated that there was no weight loss in the present study compared to the weight at initial, observation on growth and nutrient utilization revealed that growth significantly reduced as watermelon is increased in the diet. However since there was no significant differences in the protein content of the diet, differences in performance of experimental fish may be linked to superiority of protein quality of Groundnut cake which reduced as level of replacement increase. Characteristic feed utilization efficiencies and consequent growth rates has earlier been reported and attributed to dietary protein quality by Sotolu and Faturoti, (2008), however, anti-nutritional factor in raw watermelon seed may also be implicated as possible cause of significant reduction in growth. Watermelon seeds possess chemical compounds such as alkaloids, lectins and phenolic compounds such as lactones, tannins and flavonoids which probably function in the protection of seeds from microbial degradation until conditions are favourable for germination, hence, may have led to prevention of digestion in the gut of the fish (Cai *et al*., 2004; Komutarin *et al*., 2004).

It has been reported that toxic component or anti-nutritional factors in most agricultural by-products may cause irritation of digestive tract which is capable of decreasing feed intake and growth (Fakunle *et al*., 2013). Hence inclusion beyond the tolerable level of the fish lead to adverse growth consequences. Many other authors have similarly reported varied replacement level of about 50 % (Babatunde *et al*., 2001; Falaye *et al*., 1999), 60% (Olubamiwa *et al*., 2000) and 100% (Tiamiyu *et al.,* 2014) of waste and by-products with conventional once. It can be correctly inferred then that replacement of convention feeds by alternate sources of plant and animal origin, depends on the nature and composition of the unconventional feedstuffs, inclusion levels, anti-nutritional factor of feed ingredients, method of processing and the tolerance levels of the experimental fish species. Similarly, Lovel and Leary (1990) pointed out that increasing fibre content beyond the basal level could cause reduce growth of fish owing to poor digestion of cellulose. Hence, this is likely to be responsible for the poor growth performance of fish fed inclusions beyond 25% watermelon seed meal containing high crude fibre. However the result of the present study show that *Clarias gariepinus* cannot tolerate inclusion levels beyond 25% and fiber content beyond 5% as negate agreed with the recommendations of Sawaya *et al*. (1986) who stated that watermelon seed should not be included at levels higher than 20%, because these levels brings up the fiber content of the ration over 10%, which reduce feed intake. The protein efficiency ratio obtained in this study is in line with 0.31-0.52 reported by Orire and Ozoadibe (2014) for *Clarias gariepinus* fingerlings fed soybean waste. The results of feed conversion ratio in this study is higher than 1.10-1.60 reported by Ogbonna and Orire (2015) for *Clarias gariepinus* fingerlings fed graded inclusion levels of raw locust bean as replacement for fish meal and 1.02 – 1.85 as reported by Adewumi and Ola-Oladimeji (2016) on performance of catfish fed varying inclusion level of fermented mulberry leaf. The specific growth rate in this study was between 0.13 – 0.16.

Despite the significant effect observed in growth, survival of the fish fed the different diet were also affected, Basavarajah and Anthony (1997) had reported a survival rate of 98% for common carp fry fed conventional feed and 100% for fry fed supplementary feed for a 35 days feeding trial. Survival likely depend strongly on tolerance level of different fish species to the nature and level of anti-nutritional factor in the feedstuff. Carcass composition of the fish fed the experimental diets were higher in values than the those recorded in the start (Initial) of the study, protein retention was higher for the control and T2 suggesting that the protein to energy ratio used in the feed was at the right level and as a result, there was no sparing of protein for energy. The lipid content increase in this study is likely due to the fact that both groundnut cake and watermelon seeds oil seeds added to the lipid contents of the feed (Mustafa *et al*., 1972). Abbas (2007) and Manjappa *et al.* (2011) had opined that better nutrients utilization in fish carcass fed high lipids diets is related to both the dietary protein level and availability of non-protein energy sources.

CONCLUSION AND RECOMMENDATIONS

The findings of this research revealed that mean weight gain, percentage mean weight gain, specific growth rate, and feed intake, were significantly higher in treatment fed T2 (25% watermelon seed meal inclusion); however, feed conversion ratio and survival rate were significantly higher in T1 (0% watermelon seed meal inclusion). The use of watermelon seed meal as supplementary feed for *Clarias gariepinus juveniles* is highly recommended at 25% inclusion.

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EFFECT OF PROCESSED WINGED TERMITE AS FISH FEED FOR *CLARIAS GARIEPINUS* FRY

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ABSTRACT

Eight (8) weeks feeding trial was conducted to evaluate the effect of processed termite meal as a replacement for Artemia in the diet of Clarias gariepinus fry. The effects of three treatments: Artemia (WGT1), processed termite mixed with moringa extract (WGT2) and processed termite mixed with pumpkin extract (WGT3) on the growth performance, survival rate and condition factor of C. gariepinus fry were studied. Each treatment was replicated three times in a completely randomized design. One hundred (100) C. gariepinus fry were stocked per replicate. Feeding was done ad-libitum for 14 days. Water quality parameter was monitored and maintained at optimum levels for freshwater fish culture throughout the experiment. Result elucidates the significant difference in Percentage weight gain which was highest in WGT1 (396.60+0.00) and lowest in WGT3 (120.21+0.00), Specific growth rate (SGR) was significantly different among the treatments, with mean values of 11.424, 6.506 and 5.635% in WGT1, WGT2 and WGT3 respectively. The survival rate was highest in WGT2 with mean value 69.00% and least in WGT1 (66.67%). Condition factor of the fry was not significantly different among the treatments. It was concluded that Artemia significantly improved the growth of C. gariepinus fry compared to processed winged termite, but survival rate of the fry fed processed winged termites meals was significantly better than fish fed Artemia. It is recommended that processed winged termites meals can be used for feeding C. gariepinus fry in fish seed production; however, there is need for further research to improve on weight gain of the processed winged termites meals comparatively to Artemia.

Keywords: *Termite, Moringa extract and Pumpkin extract.*

INTRODUCTION

At present human population stands at 6.4 billion. It is estimated that the world's human population will be 8.1 billion in 2030 and 9 billion in 2050. The greatest increase will occur in developing countries (Roppa, 2007). This increase will lead to the animal protein requirements and demand also increasing. Therefore, there is a need to exploit not only the known unconventional feed ingredients but also to determine and introduce new and lesser known plants and animal feed resources. The availability of high-quality, low-cost feed is a crucial prerequisite for aquaculture production. Presently, the protein sources such as fishmeal are very expensive, especially for smallholder farmers. As a result, the demand for low cost fish feed is high, due to the rising cost and limited supply of commercial feeds (Mupeta *et al.,* 2003). Gope and Prasad (1993) mentioned that insects represent the cheapest source of animal protein.

Insects are believed to have a higher proportion of protein and fat than beef and fish with a high energy value. According to Bernard and Allen (1997), protein concentrations in invertebrate species range from 40 to 70% on a dry matter basis (DMB). However, little research has been conducted on the use of winged termite "Shinge" (as called in Hausa language) in the feeding of *Clarias gariepinus* fry. Therefore this study intends to provide empirical information on the use of winged termite as major ingredients in the diet of *C, gariepinus* fry.

MATERIALS AND METHODS

Experimental Set Up

The experiment was conducted at the Fisheries unit of the Experimental Farm, Nasarawa State University. Nine hundred (900) *Clarias gariepinus* fry was used for the study. Fresh pumpkin and *Moringa oleifera* leaves was obtained from Lafia central market and transported to the experimental location for extraction. Both the pumpkin and moringa juice were extracted separately. The leaves were washed with clean water, squeezed with little quantity of water and sieved with a fine sieving cloth to collect the juice.

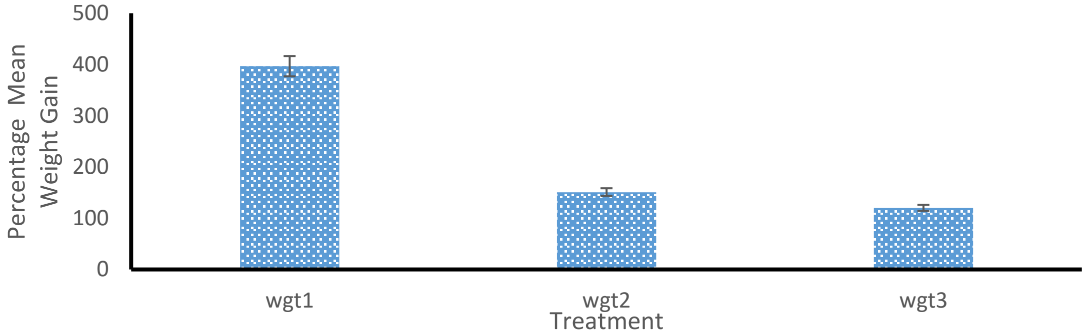
Winged termite popularly known as "*Shinge*" was obtained from Thursday market in Lafia (Alhamis market). The termites were washed with clean water so as to remove dirt and sand particles, and oven dried and grounded into powder. The grinded termite was divided into two equal portions. One part was mixed with pumpkin leave juice and dried at room temperature while the second part was mixed with moringa leave juice, dried at room temperature. These were used as the processed winged termite meals.
Water was pumped from the University's farm borehole into over-head tanks for settling after which water is released into the experimental units. Plastic bowls were used for the study. The bowls were filled with water uniformly and 100 *Clarias gariepinus* fry were randomly stocked in each bowl. The fish were starved for twenty four (24hrs) to maintain uniform stomach condition and to induce their appetite prior to the use of experimental diets.
The experiment consists of three treatments replicated three times in a completely randomized design. Treatment 1 which was the control was fed with artemia and is labeled as WGT1, treatment 2 was fed with processed winged termite mixed with pumpkin leave juice and industrial vitamin C and was labeled as WGT2 while treatment 3 was fed with processed winged termite mixed with moringa leave juice and industrial vitamin C and was labeled as WGT3. The fish was fed to satiation for two (2) weeks.
Water quality parameters (D.O, pH, temperature, carbon dioxide and ammonia) were monitored throughout the period of the experiment.

Statistical Analysis

Data obtained was analyzed using one way Analysis of variance (ANOVA) and significant mean differences was separated at 0.05 probability level as described by Steel *et al*. (1997).

RESULTS AND DISCUSSION

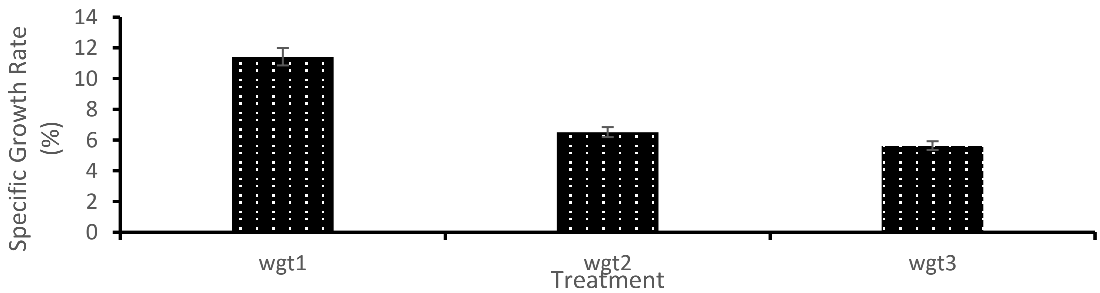
The result revealed WGT 1 feed with highest gain in specific growth rate, followed by WGT 2 feed. The better performance of WGT 1 WGT 2 could mainly be attributed to the rate of processed winged termite fed alongside with the Artemia feed, which might have led to the acceptability and efficient utility by fish.



Keys: WGT1 = Artemia, WGT 2 = winged termite mixed with moringa, WGT 3= winged termite mixed with pumpkin

Fig. 1: Percentage mean gain of C. *gariepinus* fry fed with Artemia and processed winged termite diets

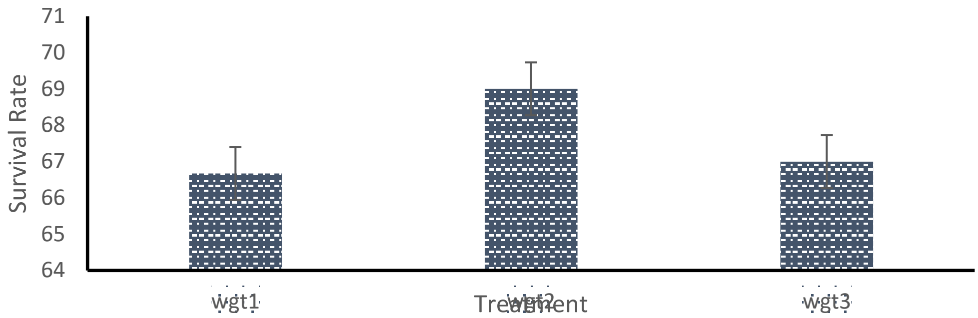
The growth of fish depends on the ingredient and it percentages in the formulated feed (Giencoss *et al.*, 1997). The result of percentage mean gain (Fig. 1) also compare well with comparative feed trials of Rahman *et al*., 1997 an Henken *et al*., 1986 who recorded best growth result for feed containing 40% and 58% crude protein respective in Clarias spp. The result agree with that of Giri *et al*., (2003) who reported an increase in body weight gain specific growth rate in post larvae of Clarias hybrid feed increase level of protein. In previous studies by (Lim *et al*., 2003) involving the larvae of African catfish, *C. gariepinus*, Artemia also gave the best growth performance in terms of weight gained. Artemia have also been reported as a good starter diet for freshwater and marine fishes (Person, 1989) because of its balanced nutritional composition.



Keys: WGT1 = Artemia, WGT 2 = winged termite mixed with moringa, WGT 3= winged termite mixed with pumpkin

Fig. 2: Specific growth rate of C. *gariepinus* fry fed with processed winged termite diets

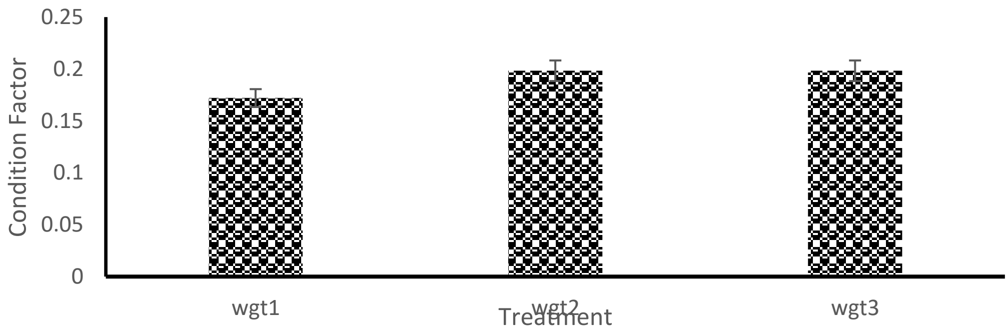
The specific growth rate (Fig. 2) obtained in this study was between 3.17 and 11.66. This result is higher than the maximum average SGR values (4.07–4.19) calculated in *Clarias gariepinus* after a 10-day feeding period with Artemia (Verreth and Den Bieman, 1987). This study agree with Agokei *et al.* (2001) who reported a higher specific growth rate value of 3.19%d^{-1} using Coppens, Multifeed, Eurogold, Vital and feed Ajanla which may be due to feeding frequency and the type of feed.



Keys: WGT1 = Artemia, WGT 2 = winged termite mixed with moringa, WGT 3= winged termite mixed with pumpkin

Fig. 3: Survival rate (SR) of *C. gariepinus* fry fed with processed winged termite diets

Survival rate (Fig. 3) was better in *C. gariepinus* fry fed with winged termite and moringa leave. This result agrees with the report of Abduraheem *et al.* (2012), who obtained lower survival in *C. gariepinus* larvae fed live feed (Artemia) and higher in artificial feeds. Like other live feeds such as Artemia, this implies that the fry did not have fully developed guts, as well as poor perception organs such as the olfactory. Even fry could die with guts full of food, suggesting their inability to digest formulated diets. Artemia showed superior growth over those fed on winged termite with Moringa leaves extract.



Keys: WGT1 = Artemia, WGT 2 = winged termite mixed with moringa, WGT 3= winged termite mixed with pumpkin

Fig. 4: Condition factor of *C. gariepinus* fry fed with processed winged termite diets

Condition factor (Fig. 4) recorded in this study is in line with the findings of Cassius *et al.* (2017) in *C. gariepinus* fed on different diets. The lower growth observed in *C. gariepinus* fry fed winged termite with pumpkin leave can be as a result of high crude protein content. Dupree and Huner (1984), reported that weight gain in fish is directly proportional to the protein content of the diet provided the levels of protein does not exceed 50%. Cho *et al*. (1985) reported a 25% crude protein in diet as adequate for catfish fry rearing in order to obtain optimum growth in intensive culture.

Table 1: Water Quality Parameters when feeing with Processed Winged Termite Diets and Artemia

Treatment	DO (mg/l)	T (°c)	pH
WGT1	7.22±0.03	27.30±0.04	7.24±0.02
WGT2	7.21±0.03	27.23±0.06	7.25±0.03
WGT3	7.22±0.03	27.3±0.02	7.23±0.03

The water quality parameters monitored were within the normal range for optimum performance of culture fish (Table1).

CONCLUSION AND RECOMMENDATIONS

It is concluded that Artemia significantly improved the growth of *C. gariepinus* fry compared to processed winged termite; however, survival rate and condition factor is significantly better than fish fed Artemia. More efforts are required to develop and test other feed ingredients or manufactured feeds of the same or better ingredients of the feed used in the study to further reduce the cost of feeds in seed production. Based on the result of this study, it is recommended that processed winged termites meals can be used for feeding *C. gariepinus* fry in fish seed production.

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ECTOPARASITES INFESTATION IN HATCHERY BRED *CLARIAS GARIEPINUS* SEEDS IN LAGOS STATE, NIGERIA

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ABSTRACT
Parasites are a menace to cultured fish affecting the health status, creating entry for secondary bacterial infection that results in economic losses, making fish production by culture unsustainable. The knowledge of the various parasites associated with hatchery propagation of fish seeds becomes important to the development of effective health management strategies, and this study seeks to investigate the occurrence and intensity of these parasites in catfish hatcheries. A total of 150 seeds of Clarias gariepinus comprising of 80 fry, 55 fingerlings and 15 juveniles were sampled from thirty randomly selected farms, and observed for the presence of parasites using standard parasitological methods. The percentage of fry, fingerlings and juveniles infected were 41.1%, 46.4% and 12.5%, respectively. The parasites observed comprised of 5 protozoans (Trichodina sp, Vorticella sp., Tetrahymena sp., Icthyobodo sp., and Chilodonella sp. and 3 metazoans (Gyrodactylus sp., Dactylogyrus sp. and Salmonichus sp.). Trichodina sp had the highest occurrence and load in all developmental stages (fry: 22.6 and 46.5 %; fingerling: 60 and 86 %; juvenile: 33.3 % for both), than the other parasites, especially under the intensive system. However, the occurrence of Dactylogyrus sp (Monogenea) was higher (48.4 %) than Trichodina sp in the fry, under the intensive system. The occurrence and load of the parasites were more on the gills than the skin. The predominant source of water was borehole (86.7%), and the prevalent values of water quality parameters (pH, water temperature, dissolved oxygen, ammonia, nitrite and iron) were within acceptable range. Parasite occurrence and load were generally higher under the intensive rearing system for the various developmental stages of Clarias gariepinus..
Keywords: *Parasites, Clarias gariepinus, management, hatcheries, fish seeds.*

INTRODUCTION
The sustenance of aquaculture industry depends on production and availability of quality fish seeds ranging from fry, fingerlings and juveniles. The production yield may be influenced by certain factors such as availability and effective utilization of water, quality feeds, intensification of fish production and other production inputs (Oladosu *et al.*, 2012). However, increase in the level of culture intensification subjects fish culture to higher risk of disease occurrence (Schlotfeldt, 1981). The persistent build up of organic wastes coupled with poor water quality requires regular water renewal to possibly prevent susceptibility of cultured fish to rapid transmission of occasional pathogens (Oladosu *et al*., 2012 and Paperna, 1991).

Parasites occur in different groups ranging from protozoans, helminthes, arthropods and other miscellaneous taxa producing harmful effects on their host (Paperna, 1996). Although, ectoparasites are fondly found in tropic water than endoparasites (El-Seify *et al*. 2011). All the parasites derive food and nutrient from their host which could possibly lead to decrease in growth rate and atime mortality resulting to loss of investment (Khalil and Polling, 1997). The outbreak of disease in fish farming is one of the raging challenges that can easily devastate production processes and cause economic loss (World Bank, 1997), as buttressed by the global estimate loss in aquaculture to disease, to the tune above US$ 6 billion per annum (World bank, 2014). Recently, attention has been shifted gradually to fish parasites in culture systems due to increase in aquaculture practices. Parasites of fish negatively affect the immune system of their host, resulting to nutritional deficiency, susceptibility to secondary infections, energy loss, mortality and economic loss (Onyedineke *et al.*, 2010). The fish seeds as a product of infected hatcheries could be a pathogen carrier to the grow–out systems where disease can manifest rapidly and cause mortality of the stocked seeds.

Incidence of parasitic infestation on *C. gariepinus* fry reared under different culture systems has been previously reported (Oladosu *et al.*, 2012), the juveniles of *Clarias* sp and H*eterobranchus* sp in hatcheries in southern Nigeria (Obiekezie and Ekanem 1995) and high mortality of fry, fingerlings and juveniles of carp, eel and catfish reared under intensive water recirculating system (Schlotfeldt and Alderman,1995). However, information on parasitic infestation in fish seeds (fry, fingerlings and juvenile) production under different culture intensity (Intensive and semi - intensive culture systems) in tropical environment is by no means exhaustive, necessitating this study.

MATERIALS AND METHODS

Fish Sampling

A total of 30 fish hatcheries were randomly selected. The fish seeds at the point of visit were collected to erode bias, resulted to 80 fry, 55 fingerlings and 15 juveniles using scoop nets. Five samples of each developmental stage of fish seeds were collected for laboratory analysis. A labeled 10 – litre kegs used for respective collection of the fish seeds prior to clinical examination.

Water Sampling

Physico-chemical parameters of water collected from the rearing facilities where the fish seeds were sampled were measured. Dissolved oxygen (DO) and water temperature were measured *in situ* using a digital oxygen meter (Hanna HI9146 – 04 with a probe HI76407/4F). The pH was measured using a pocket-type Hanna digital pH meter ((HI98103). A commercial colorimetric test kits Hanna – H13824 – 025 and HC960475 were used respectively to measure the ammonia and nitrite content according to the instruction of the manufacturers. The values of water quality parameters were recorded for the hatcheries, culture systems and the different developmental stages.

Clinical examination of fish seeds samples

Five samples of each fish seed type were collected and examined for parasitic infections. The fingerlings and juveniles were immobilized by severing the vertebral column with a pair of scissors just behind the head, while the fry slightly compressed with the aid of forceps to restrain the specimen for examination. The whole fry was placed on glass slides, two drops of normal saline were placed on each fry prior to microscopic examination to avoid dryness thereby preserving the parasites to be examined (Oladosu *et al*., 2012).

Five fingerlings and juveniles were clinically and microscopically examined from selected farms. On each sample, skin smear was collected using cover slip to longitudinally scrape the body of the fish, placed on a clean glass slide and kept moist by applying a drop of saline at the edge of the cover-slip covering the smear on the glass slide. The opercula plate of each of the fingerlings and juveniles was slit opened and a gill arch was detached using forceps and scissors. One gill arch each from respective fish seed was placed on a glass slide and kept wet with a drop of saline to prevent dehydration of the parasites by the microscope light before completing the microscopic procedure. The procedures for clinical examination carried out followed the descriptions of Noga (1995) and Oladosu *et al.,* (2012).

Identification of parasites

Parasites from the skin smears and gills collected from fingerlings, juveniles, and fry were observed under a binocular microscope (Olympus). The parasites were captured using a digital camera (Scopephoto DCM 35E – 350K Pixels) inserted into one of the eyepiece holders of the microscope. The camera was connected to a laptop computer unit to capture the image of the parasites. The images of the parasites obtained were compared with those earlier described (Paperna, 1980 and Noga, 1995). Parasites were identified to genus level according to the description of (Noga, 1995 and Schlotffeldt and Alderman, 1995), and ascertained with the identification keys by Paperna (1980). Microscopic observation was done at magnification of x40 and x100.

RESULTS

One hundred and fifty fish seeds comprising of 80 fry, 55 fingerlings and 15 juveniles were sampled from thirty randomly selected farms, out of which 23, 26 and 7, respective fish seeds were infected (Table 1). Table 2 shows the culture practices management of the catfish hatchery visited. The culture system used by the respondents were intensive farming (66.7%) and semi – intensive (33.3%). No fish breeder used extensive system of farming. The major source of water was borehole (86.7%) while 13.3% depended on well water. Majority of the breeders (46.7%) adopted tarpaulin vats compared to concrete tanks (26.7%) and plastic tanks (26.7%) with 60% farmers operating flow through rate of water renewal.

Table 1: Occurrence of parasitic infestation in different seeds of *Clarias gariepinus*

Developmental Stage of fish Seeds	Numbers of fish farms	Number of fish examined	Numbers of fish infested	Percentage of infested fish (%)
Fry	16	80	23	41.1
Fingerlings	11	55	26	46.4
Juveniles	3	15	7	12.5
Total	30	150	56	100

Table 2: Culture / management practices observed in the hatcheries

		Freq.	%
Source of water:	Borehole	26	86.7
	Well	4	13.3
Culture facilities	Concrete tank	8	26.7
	Plastic tank	8	26.7
	Tarpaulin vats	14	46.7
Level of intensification:	Intensive	20	66.7
	Semi – intensive	10	33.3
Water exchange/week:	Flow-through	18	60
3 – 4 times		8	26.7
1 – 2 times		4	13.3

The parasitic fauna observed in this study (Table 6) comprised of 5 protozoans (*Trichodina* sp, *Vorticella* sp., *Tetrahymena* sp., *Icthyobodo* sp., and *Chilodonella* sp.) and 3 metazoans (*Gyrodactylus* sp., *Dactylogyrus* sp. and *Salmonichus* sp.). Production of fry under intensive culture showed 23 infected fry from 11 farms with highest prevalence of *Dactylogyrus* sp., (48.5%) but the highest load of trichonids (180) (Table 3). Twenty – three (23) infected fingerlings from 9 farms recorded *Trichodina* sp., both for highest prevalence (60%) and load (414) followed by *Dactylogyrus* sp (20% and 48) respectively (Table 4). Other parasites identified on the fry reared under intensive culture were *Vorticella* sp (25.8%) and *Salmonichus* sp (0.3%). The fingerlings reared under intensive culture revealed more parasites with 2.9% minimal prevalence of *Gyrodactylus* sp., *Ambiphyra* sp., *Tetrahymena* sp., *Ichthyobodo* sp., and *Chilodonella* sp., respectively while *Vorticella* sp. recorded 5.7%. No parasite was obtained from juvenile produced under intensive culture (Table 4).

The semi – intensive production recorded 30% parasitic infections in fingerlings from 2 farms with 28.6% prevalence in *Trichodina* sp., *Dactylogyrus* sp., and *Gyrodactylus* sp., respectively but highest load of 101 *Trichodina* sp. was recorded. 46.7% of juveniles were infected under semi – intensive production with highest prevalence of *Dactylogyrus* sp. (55.6%), but the lowest prevalence of *Gyrodactylus* sp. (11.1%) recorded the highest parasitic load of 13 individuals (Table 5). No breeder produced fry under semi – intensive system during the time of study.

The distribution of parasites on the sites of infection on the fry, fingerlings and juveniles showed that *Trichodina* sp was most prevalent parasites followed by *Dactylogyrus* sp. while the least was *Salmonichus* sp. (Table 6). *Trichodina* burden was found more on the skin of the fry (117) and fingerlings (366) while *Dactylogyrus* burden was recorded more on the gills of fry (120) and fingerlings (56). *Gyrodactylus* sp invaded the skin of fingerlings and juveniles with prevalence rate of 85.7% and 100% respectively. Other parasites were found to be site specific as recorded on the skin of the fry (*Salmonichus* sp.,), and the fingerlings (*Vorticella* sp., *Ambiphyra* sp., *Tetrahymena* sp., *Icthyobodo* sp., and *Chilodonella* sp.).

Table 3: Parasitic infestations and load of parasites on *Clarias gariepinus* fry under different levels of culture intensity

Culture Intensity	Numbers Examined & infested	Taxa of parasites	Freq. of occurrence	Percentage of occurrence	Total loads of parasites	Percentage loads of parasites(%)
Intensive	55/23 (41.8)	*Trichodina* sp	7	22.6	180	46.5
		Dactylogyrus sp	15	48.4	132	34.1
		Vorticella sp	8	25.8	74	19.1
		Salmonichus sp	1	3.2	1	0.3
Semi - intensive	25/0 (0)	Nil	0	0	0	0

Table 4: Parasitic infestations and load of parasites on *Clarias gariepinus* fingerlings under different levels of culture intensity

Culture Intensity	Numbers Examined & infested	Taxa of parasites	Freq. of occurrence	Percentage of occurrence	Total loads of parasites	Percentage loads of parasites (%)
Intensive	45/23 (51.1)	*Trichodina* sp	21	60	414	81
		Dactylogyrus sp	7	20	48	9.4
		Gyrodactylus sp	1	2.9	4	0.8
		Ambiphyra sp	1	2.9	22	4.3
		Vorticella sp	2	5.7	6	1.2
		Tetrahymena sp	1	2.9	6	1.2
		Icthyobodo sp	1	2.9	5	1.0
		Chilodonella sp	1	2.9	6	1.2
Semi - intensive	10/3 (30)	*Trichodina* sp	2	28.6	101	72.7
		Dactylogyrus sp	2	28.6	8	5.8
		Gyrodactylus sp	2	28.6	24	17.3
		Vorticella sp	1	14.3	6	4.3

Table 5: Parasitic infestations and load of parasites on *Clarias gariepinus* juveniles under different levels of culture intensity

Culture Intensity	Numbers Examined & infested	Taxa of parasites	Freq. of occurrence	Percentage of occurrence	Total loads of parasites	Percentage loads of parasites(%)
Intensive	0	0	0	0	0	0
Semi – Intensive	15/7 (46.7)	*Trichodina* sp	3	33.3	11	33.3
		Dactylogyrus sp	5	55.6	9	27.3
		Gyrodactylus sp	1	11.1	13	39.4

Table 6: Distribution of parasites on sites of attack on *Clarias gariepinus* seeds in hatchery farms

	Fry				Fingerlings				Juveniles			
Parasites species	Skin	%	Gills	%	Skin	%	Gills	%	Skin	%	Gills	%
Trichodina sp	117	65	63	35	366	71.8	144	28.2	5	71.4	2	28.6
Dactylogyrus sp	12	9.1	120	90.9	0	0	56	100	0	0	8	100
Vorticella sp	20	100	0	0	12	100	0	0	0	0	0	0
Gyrodactylus sp	0	0	0	0	24	85.7	4	14.3	13	100	0	0
Ambiphyra sp	0	0	0	0	22	100	0	0	0	0	0	0
Tetrahymena sp	0	0	0	0	6	100	0	0	0	0	0	0
Icthyobodo sp	0	0	0	0	5	100	0	0	0	0	0	0
Chilodonella sp	0	0	0	0	6	100	0	0	0	0	0	0
Salmonichus sp	1	100	0	0	0	0	0	0	0	0	0	0

The prevailing environmental conditions for fry, fingerlings and juveniles reared under the different culture systems in this study were reported in table 7. The water quality parameters recorded were water temperature, pH, dissolved oxygen, ammonia, nitrite and iron. They were all at acceptable range except the lowest dissolved oxygen and highest nitrite values recorded in juveniles produced in plastic tank.

Table 7: Mean physico – chemical parameters of infected hatcheries operating under different culture systems

Culture Systems	Fish Stage	Water temp. (°C)	pH	Dissolved Oxygen (mgl^{-1})	Ammonia (mgl^{-1})	Nitrite (mgl^{-1})	Iron (mgl^{-1})
Concrete tanks	Fry	30.2	6.92	4.57	2.80	0.36	0.60
	Fingerlings	31.1	6.76	7.67	2.70	0.47	0.27
	Juveniles	30.8	5.87	9.74	2.90	0.60	0.00
Plastic tanks	Fry	29.8	6.90	3.69	0.30	0.51	0.00
	Fingerlings	28.9	7.41	4.14	0.30	0.46	0.40
	Juveniles	31.8	6.70	0.21	2.90	3.60	0.60
Tarpaulin	Fry	30.6	6.94	5.58	2.20	1.24	0.00
	Fingerlings	30.2	7.39	2.66	2.32	0.48	0.32
	Juveniles	26.4	7.30	10.24	2.80	1.31	0.80

pH = Hydrogen ion concentration, Water temp. = Water temperature

DISCUSSIONS

Infestation of parasites spread through the culture systems in various degree despite the efforts of the breeders to maintain high water budgets by using borehole (86.7%), flow through (60%), fish seeds fed with imported feeds and feeding regime of 3 – 4 times daily. This may suggest that other prevailing factors related to production process such as usage of contaminated hatchery materials, rearing conditions, stocking density, handling, availability of oxygen and seasonality may be contributing to parasites propagation (Firmino *et al.*, 2019). The prevalence of protozoans and monogenean trematodes recorded in the study possibly complied with the research report that parasitic infestations are often recorded in ponds used every year to rear fry especially where infections have been previously noticed which commonly increase rate of mortality (Paperna, 1963a). The distribution of parasites recorded in this study predominantly found on the skin, gills or both which agreed with the reports of *Abowei (2011). Trichodina* sp was commonly found on the skin and gills of fry (117, 63) fingerlings (366, 144) and juveniles (5,2) respectively which conformed with the report that trichonids are true parasites of fish mostly found on the skin and gills of culturable fish species (Paperna, 1980).

The second most distributed parasites was *Dactylogyrus* sp., found on the gills of all the fish seeds with atleast 90% occurrence but only found on fry skin with 12 individuals. This reports agreed with the study carried out in Delta State with *Dactylogyrus* sp absent on the skin of *Clarias gariepinus* fingerlings but contrary to its presence on the gills of fry and fingerlings (Okunade *et al.*, 2018). *Gyrodactylus* sp., was found both on the skin and gills of the fingerlings and only the skin of the juveniles with no record on the fry. The finding was contrary to the reports obtained on *Clarias gariepinus* in Delta State probably because of geographical location and other factors (Okunade *et al.*, 2018). Moreover, Monogenea are found to exhibit both host and organ specificity indicating that some species could attack the skin while some on gills of freshwater fish (Öztürk and Özer, 2014). Nevertheless, *Dactylogyrus* sp commonly infest the gills while *Gyrodactylus* sp on skin (Reed *et al*., 1996). Infestation rate of monogeneans were higher in this study which could be as a result of high reproductive capacity of the parasite reported by Paperna, (1996).

Other parasites were found to be skin specific on fry (*Vorticella* sp and Suspected *Salmonichus* sp.,) and fingerlings (*Vorticella* sp., *Ambiphyra* sp., *Tetrahymena* sp., *Icthyobodo* sp., and *Chilodonella* sp.). These parasites were not recovered on juveniles skin or gills. The finding was contrary to the report that most of these parasites were found on both the skin and the gills of culturable fish species (Hoffman *et al.*, 1979; Imai *et al.*, 1984, Paperna and Van As, 1983). The absence of these parasites on juveniles may be that they developed more defensive mechanism than others.

The higher intensification (intensive culture) recovered more load of parasites like *Trichodina* sp., *Dactylogyrus* sp. and *Vorticella* sp., on fry and *Trichodina* sp., *Dactylogyrus* sp., and *Ambiphyra* sp., on fingerlings which may be due to polluted water environment as a result of overfeeding, overcrowding and stress caused by frequent handling through sorting. However, the juveniles suffers less parasitic load of *Trichodina* sp than fingerlings under semi – intensive culture which may be as a result of better environment created after sorting in terms of low stocking density and better innate immunity with growth as a factor in parasitic resistance.

The water quality recorded were within the acceptable range for *Clarias gariepinus* in all the cultured systems except the high depletion of dissolved oxygen in juveniles reared in plastic tanks which may be due to utilization of more oxygen for their metabolic activities and ability to use the lung like structures to breathe – in atmospheric air. The fish were able to withstand the varied water values in different culture systems because of reasonable water renewal pattern adopted.

CONCLUSION

Some of the hatcheries encountered parasitic infestations despite the used of borehole as their major source of water and quality feeds which depicted the possibility of other factors responsible for parasitic infestations such as inoculation of uninfected culture water with infected water, overstocking, inadequate and untimely sorting and usage of non-disinfected hatchery materials. The study showed that ectoparasites are highly prevalent in *Clarias gariepinus* fish seeds production. As fish breeders usually channeled their resources and efforts to maximize their productions, intensive culture systems must be adequately regulated within the required inputs to avoid pathogenic infections that can expose their investment to unguided risk leading to economic loss. Therefore, good aquaculture practices are recommended to improve the welfare of the fish in the hatcheries.

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PROFITABILITY ANALYSIS OF MARKETING OF SELECTED NON-TIMBER FOREST PRODUCTS (NTFPS) IN ENUGU STATE, NIGERIA

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ABSTRACT
Non-timber forest products (NTFPs) play a significant role in the livelihoods of the rural households through trade. In this study the profitability analysis of selected non-timber food products in Enugu state of Nigeria was examined. Specifically, the study aimed to identify the socio-economic characteristics of the respondents; it also determined the current income from marketing of the selected non-timber forest products. Furthermore, the study focus was to ascertain the profitability of selected NTFPS marketing as well as the constraints facing marketing of NTFPs in the study area. Sampling technique used was purposive where (102) marketers were interviewed. Data collected came from primary sources with well-structured questionnaire. Multiple regression, gross margin and descriptive statistics were used to analyze collected data. The findings show that it is profitable to commercialize selected non timber forest product in the study area. From to the study, 75% of the respondents involved in marketing are females, as 87% of the respondents were unaware of extension agent. Added to this, only 78% of the respondents stated that most non-timber forest products are seasonal but 73% of the respondents indicated that their reasons for marketing of NTFPs are as source of livelihood. The study indicated from cost and return analysis that marketer realizes for every ₦1 invested in the marketing of selected NTFPs, ₦12.3, ₦7.3, ₦3.5, ₦1.0, ₦2.0 and ₦3.8 for achi, akpalata, African bush pear, African oil bean, African bread fruit, and bush-meat respectively. Additionally, the research shows the coefficient of age, marital status, seasonality, access to extension agent and household size were significant variables that influences the profitability of marketers of selected NTFPs in the study area. The constraints identified include seasonality of products, lack of funds, extension services, and price fluctuation amongst others. The study recommended that the government should offer credit facilities through commercial banks and bank of agriculture to motivate young people in marketing of selected NTFPs business since it is a profitable and sustainable enterprise. Besides, government should implement good pricing system, relevant laws and harvest guide regulation for sustainability of non-timber forest products. Finally, modern storage, processing and preserving facilities should be provided to improve shelf-life which in turn increases availability of NTFPs after harvest by different levels of government.
Keywords: *Profitability, Marketing and NTFPs*

INTRODUCTION
The NTFPs constitute an important source of livelihood for millions of people across the world, and research have shown that there are more than 500 million people that are highly dependent on forest resources, particularly the NTFPs, in Latin America, sub-Saharan Africa, (SSA) and South- eastern Asia (Shackleton *et al*., 2007). The NTFPs provide about 17 million and 30 million full-time jobs in the formal and informal sectors as well as 13-35% of all rural non-farm employment in developing countries like Nigeria and in Enugu state (Duong, 2008).
In addition to their wide industrial applications in developed countries, non-timber forest products (NTFPs) are consumed locally and are used in religious and cultural rituals (Chikamai et al., 2008). Non-timber forest products represent income opportunities from forest that do not involve cutting down trees for wood products. In forest with low timber production potential, non-timber forest products represent the major or potential source of income, traditionally used and appreciated by people of many cultures worldwide (Odeyale and Olawuyi, 2018). The significance of these products for sustainable economic growth, cultural endurance and environmental health is receiving increasing recognition by government and other official agencies (Bonet et al., 2009).

According to Nzeh and Eboh (2007), forest contribute directly and indirectly to rural household livelihood through the generation of income and employment from the sale and exchange of gathered and unprocessed non-timber forest products such as firewood. The term non-timber forest products (NTFPs) emerged as an umbrella to recognize the products derived from these various forest resources as a group such as bush meat, fuel wood, herbs, fruits etc. (Ibrahim et.al., 2016). The commercial potential of non-timber forest products (NTFPs) has received increasing interest throughout the world, not only in the developing and emerging economies, where NTFPs are an important means to alleviate poverty and address conservation concerns. Therefore, forest resources, particularly the non-timber forest products (NTFPs) have been established as an essential source of livelihood income for the majority of forest dependent communities among others. Non-timber forest products (NTFPs) - have the potential to become substantial sources of revenue, but in many communities they are underexploited. In some cases, people make considerable use of the products, but their commercial value is low.

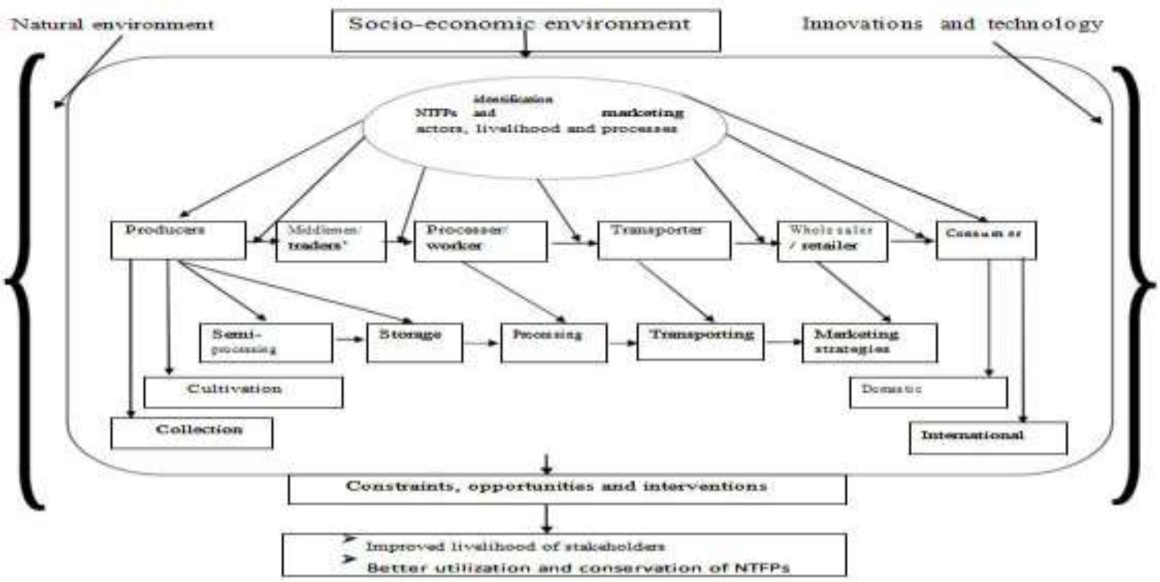
One of the difficulties for small-scale producers who seek to commercialize NTFPs is that often the markets for these products are relatively complex compared to those for timber and more traditional agriculture goods. Many NTFPs occupy "niche" markets, which tend to be small and dispersed. In addition, there are few established standards for NTFPs, and consumer preferences for products may vary considerably depending on such factors as the type of market (tourist or local) and the time of year. Prices for NTFPS vary from place to place as well as over time. Buyers may impose different quality control standards. All of these factors contribute to the complexity of NTFPS markets.

Despite the increasing research efforts, the business potential of NTFPs is still strongly underutilized; there are various challenges that hinder the development of the NTFP sector in Nigeria and the study area. Studies on the supply chains of NTFPs have revealed the key challenges at specific points of the chain, these challenges are scarcity of raw material (in terms of both quantity and seasonal availability), low market transparency, lack of business and marketing skills, small market size and high production and transport costs. In addition, it is however noted that NTFPs are continually diminishing resources as a result of their dependency on land which is usually under the pressure of depletion from agriculture and development of public infrastructures. The NTFPs constitute a critical component of food security and they are important sources of income for the rural poor in Nigeria even in the study area.

Despite their importance to forest-dependent people worldwide, accurate information on income effect on marketing of NTFPs is limited and often mixed with agricultural production statistics. This study therefore is designed at assessing the profitability of marketing of selected non- timber forest products in Enugu state. The research specifically examined the socio- economic characteristics of respondents in the study area, identify the availability status of non- timber forest products in the study area, determine the current income of marketers of selected non-timber forest products in Enugu state, analyzed the profitability indicators of non- timber forest products marketers in the study area and lastly, identify the constraints associated with marketing of non- timber forest products in the study area.

Literature Review

Conceptual Framework

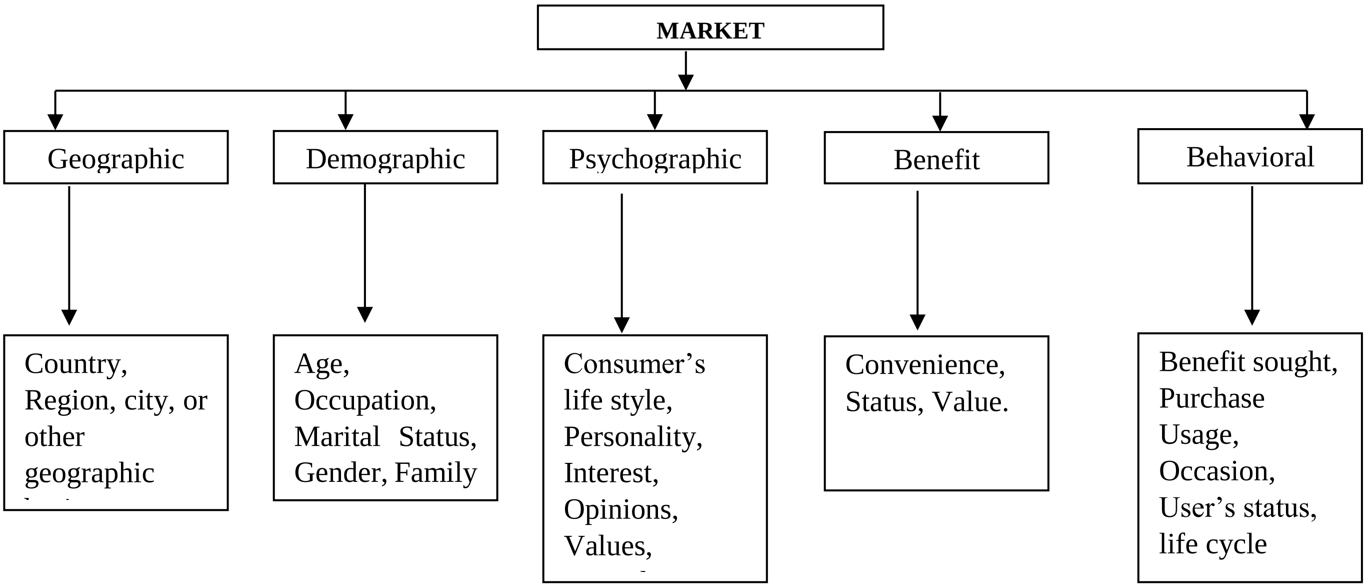


Source: Adapted from Nzeh et al (2018)

In Figure 1 above, using the production consumption system approach (PCS),it analyses the full range actors and function that are involved in all activities of NTFPs production and it encourages development of basic understanding of the system and helps to identify the most important stakeholders, their constraints and opportunities. It shows a framework within which to organize issues that needs to be considered in developing NTFPs. Its attention is focused on the market, with emphasis on the linkage between a point of transformation amongst firms at any particular point of transformation, which distinguishes PCS approach from other analytical tools such as market chain analysis and subsector analysis.

Theoretical Framework

This study is anchored on two theories. The first is production theory, Production refers to the principle to be applied in making production decisions (Oji, 2002), production decision include the decision to acquire resources, utilize resources, organize production, distribute the product of the productive activity in general to manage the services of production resources. According to Saari (2006) production theory is the study or the economic process of converting inputs into outputs including that of the NTFPs. Therefore, production talks about the act of creating an output, goods and services which adds value and contributes to utility to the society at large and also the firm itself. The second theory, marketing discusses the strong linkage between the producers and customers.



Source: Adapted from www.marketingguide.com (retrieved 2021)

Segmentation based on consumer is a definable characteristic, identity or behavior of an individual consumer that can be utilized to classify consumer into related groups. A market segmentation base is simply the factor that is used to define overall market up to into its individual market segments. These factors include description of the consumer, usually relating to their lifestyle, purchasing behavior, goals or life stage attributes.

Analytical Framework

The analysis for the study involved using descriptive statistics and other analytical tools. Meanwhile, budgetary analysis was used to determine the profitability of NTFPs marketed i.e.

TC = TFC +TVC
GM = TR – TVC
NI = TR -TC
PI = NI/ TR
BCR =TR/TC

Where:

TC = Total Cost
TVC = Total Variable Cost
TFC = Total Fixed Cost
TR = Total Revenue
GM = Gross Margin
NI = Net Income
PI = Profit Index
BCR = Benefit Cost Ratio

Furthermore, multiple regression model was used to analyze some critical objectives in the study, and it is represented below as:

$Y = b_o + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + + b_9X_9 + b_{10}X_{10} + \mu.$

Where,

Y = Income of forest marketers (annual sales in Naira),

X_1 = Age (number),

X_2 = Gender (dummy),

X_3 = Educational level (number of years in formal school),

X_4 = Martial status (dummy),

X_5 = Years of experience (number of years in marketing NTFPs),

X_6 = Access to market [distance from home to market (Km)],

X_7 = Seasonality of forest products (dummy),

X_8 = Access to extension agents (frequency of visit),

X_9 = Household size (number),

X_{10} = Access to credit (in Naira),

μ = error term

RESULT AND DISCUSSION

The socio-economic status considered in study includes, gender, age, marital status, educational status, religion, household-size, awareness of extension to the marketers and years of experience.

Table 1: Distribution of respondents according to socio- economic characteristics.

Variable	Frequency	Percentage (%)	Mean(X)
Gender			
Male	21	21	
Female	81	79	
Age			
≤ 15	7	7	
16- 30	33	32	
31 – 45	45	44	
≥ 46	17	17	
Marital Status			
Single	25	24	
Married	57	56	
Divorced	3	3	
Widowed	10	10	
Separated	7	7	
Educational Status			
No formal education	44	43	
Primary education	25	24	
Secondary education	20	20	
Post-Secondary education	13	13	
Religion			
Christian	92	90	
Traditionalist	10	10	
Household size			
≤ 4	50	49	
5 – 8	44	43	
9 – 12	6	6	
≥ 13	2	2	
Extension agents awareness			
Yes	13	13	
No	89	87	

Visits by extension agents		
Monthly	2	15
Bi–monthly	3	23
No visit	8	62
Extension agents services		
Information on forest credit	2	17
Information on NTFPs modern technology (processing only)	5	41
Information on marketing of NTFPs	3	25
Information on government policy	2	17
Years of experience		
<u><</u>5	45	44
6 – 10	33	32
11 – 15	17	17
<u>></u> 16	7	7

Source: Field survey, 2022.

The Table 1 above shows that 79% of the respondents that are involved in NTFPS marketing are females and as only 21% of the respondents are male. The greater number of females does not presuppose out-rightly that females outnumber the males in the study area. This implies that greater proportion of the marketers of NTFPs were females. Rather it can be attributed to females being more interested in marketing of NTFPs than males (Nzeh 2012). This confirms the findings of (Patience e.t.al 2019), that generally the women are more active in marketing, the high presence of women in NTFPs marketing is an indication that this activity is an important source of livelihood to generate income.

Furthermore, Table 1 reveals that 44% of the respondents falls within the age bracket between 35-45years, as it can be seen that 32% of the respondents falls within the age bracket between 25-35years. The age bracket of $\geq$45years and above constitute 17 % but barely 7% of the respondents falls within the age brackets between $\leq$18-25years. The result shows the high proportion of marketers of NTFPs in the study area falls within the middle-age bracket. From the above table 1, the youths appear uninterested in marketing of NTFPs. However, the proportion of people engaged in marketing of NTFPs with respect to age should favor both income and employment generation.

Generally, education broadens the horizon of human activities, operation and understanding of his/her environment. The educational status of individuals assist the person more access to government programmes, production credit, improved technologies and membership of rural institutions (cooperatives). According to table 1 above, it revealed that 43% of the respondents indicate no formal education in the study area. Also the same table 1 shows that 24% of the respondents agreed that they had primary education as 20% and 13% of the respondents respectively stated that they had secondary and post-secondary education. This means, NTFPs marketing constitutes a source of livelihood for both the literates and illiterates in the study area.

From the table 1 above, it illustrates that majority 90% of the respondents are Christians while 10% of the respondents are traditionalist. However, one should not be quick to assert that Christians dominate the study area, even though this seems to be the picture. In any case, both Christianity and traditional religion dominate other types of religion in the study area.

More critical findings as revealed in table 1 shows that greater proportion of the respondents (87%) are not aware of forest extension agent while 13% of the respondents are aware of the forest extension agent. This simply indicates that the few percentages of respondents with forest extension services knowledge may not be connected with those living nearer government forest reserve areas. Also as indicated that many respondents are not knowledgeable about extension services, it will result to either over exploitation or under exploitation of forest product resources thereby resulting to reduction in income generated by them. It implies that there is need for more extension agent to visit the study area.

Table 2: Distribution of some major NTFPs in the study area.

S/N	Common names	Scientific name	Part used
1	Achi	*BrachystegaEurcyloma*	Seed
2	Mushroom	*Agaricus bispous*	Plant
3	African breadfruit (ukwa)	*Treculia Africana*	Fruit
4	Rabbit (ewi ani)	*Oryctolagnus cuniculus*	Meat / bones

5	African bush pear (ube)	*Darryodes Edulis*	Fruit
6	African oil bean (ugba)	*Pentaclethra macrophylla*	Fruit
7	African oak (Akpalata)	*Afzelia Africana*	Seed
8	Grasscutter (Nchi)	*Throyonomisswinderianus*	Meat /bones
9	African Guinea pepper (uda)	*Xylopia aethiopica*	Seed
10	African nutmeg (ehuru)	*Mandora myistica*	Seed
11	Africa star apple (udara)	*Chrysophyllumaldidum*	Fruit
12	African bush mango (ogbono)	*Irvingagabonensis*	Fruit
13	Bitter kola (Akilu)	*Garcinia cola*	Fruit
14	Wild spinach (ukazi)	*Gnetumafricanum*	Leaf
15	Bush buck (utazi)	*Gongronemalatifolium*	Leaf
16	Guinea cubeb (uziza)	*Piper guineense*	Leaf / seed
17	Winged termites (aku)	*Isoptera blattodea*	Insect
18	Oil palm (akwu)	*Elaiesguinensis*	Fruit
19	Snail (eju)	*Achatina achatina*	Meat / shell
20	Hare (egenbe)	*Lepus timidus*	Meat / bones
21	land squirrel (ulili)	*Spermophiluscolumbianus*	Meat / bones
22	Bitter leaf (onugbo)	*Vernomiaamygdlania*	Leaf
23	Cashew	*Anarcadium occidentalis*	Fruit/ seed
24	Calabash (ebele)	*Lagenaria siceraria*	Fruit
25	Sponge gourd /loofah plant (ogbo)	*Luffa aegyptiaca*	Fruit
26	African velvet tamarind(icheku)	*Dialiumguineense*	Fruit/leaf/wood/bark
27	Fuel wood (nku)	*NA*	Twig
28	Monkey kola (achicha)	*Cola parchycarpa*	Fruit
29	African olive (ube mgba)	*Canarium schweinfurthii*	Fruit
30	White rubber vine (utu isienyi)	*Landolphiaowariensis*	Fruit/leaf

Source: field survey, 2022.
NA - not available**

Summarily, Table 2 above shows some of the very fundamental NTFPs in the study area. These listed NTFPs are marketable in the state. They help to generate income and employment in Enugu State as reported by Nzeh, Eboh and Nweze (2018). Literature shows that as these NTFPs create both income and employment to the rural households it assist in the poverty reduction in these communities.

Table 3: Cost and return of selected non-timber forest products in the study area.

S/N	**Items**	**Selected non-timber forest products and cost**					
		Achi	Akpalata	African bush pear (ube)	African oil bean (ugba)	African bread fruit (ukwa)	Bushmeat
A	Total revenue	5,326,000	2,919,000	75,500	1,644,000	76,000	44,800
B	Variable cost						
	Processing	112,700	58700	-	-	`-	1,500
	Packaging	139,300	130,350	7,700	21,300	8,270	2,500
	Transportation	110,000	107,000	26,500	71,000	17,600	13,000
	Total variable cost	362,000	296,050	34,200	92,300	25,870	17,000
C	Fixed cost on depreciation						
	Table	25,000	`7,600	-	-	-	5,250
	Grinder	38,000	54,000	-	-	-	-
	Measuring cups	730	5,025	-	4,745	2,225	-
	Measuring spoon	800	950	-	-	-	-
	Jute bag	5,500	8,475	5,025	5,700	6,100	1,700
	Knife	-	-	-	1,500	-	1800
	Basket	-	-	8,600	8,100	-	-
	Tray	1,960	5,400	-	2,975	5,075	-

Polythene sheet	-	18,700	6,550	13,650	-	-
Trap	-	-	-	-	-	-
Dryer/grill	-	-	-	-	-	7,300
Grater	-	-	-	5,340	-	-
Total fixed cost	70,240	100,750	20,175	42,010	13,400	16050
Total cost (TFC + TVC)	432,400	396,800	54,375	134,310	39,270	33,050
Gross margin (TR-TVC)	4,964,000	2,622,950	41300	1,551,700	50,130	27.800
Net income (TR-TC)	4,893,760	2,522,200	21,125	1,509,690	36,730	11,750
Profit index (NI/TR)	0.9	0.8	0.2	0.9	0.4	0.2
Benefit cost ratio (TR/TC)	12.3	7.3	3.5	1.0	2.0	3.8

Source: Field survey, 2022

In Table 3, the results of the analysis carried out shows that total revenue of ₦5,326, 000, ₦2,919,000, ₦75, 500, ₦1,644,000, ₦76,000, ₦44,800 were gotten from the sale of *achi, akpalata*, African bush pear (*ube*), African oil bean (*ugba*), African bread fruit (*ukwa*), and bus hmeat. A gross margin of; ₦4,964,000 for *achi*, ₦2,622,950 for *akpalata*, ₦41,300 for African bush pear (*ube*), ₦1,551,700 for African oil bean, ₦50,130 for African bread fruit and ₦27,800 for bush meat, also a net income of ₦4,893,760,-₦2,522,200, ₦21,125,-₦1,509,690, ₦36,730 and ₦11, 750, respectively.

The benefit cost ratio shows that for every ₦1 the marketer put into marketing of selected NTFPs, ₦12.3, ₦7.3, ₦3.5, ₦1.0, ₦2.0 and ₦3.8 is realized for *achi, akpalata*, African bush pear, African oil bean, African bread fruit, and bush meat respectively.

Table 4. Summary of Estimated Regression result

Explanatory Variables	**Linear**	**Semi-log**	**Double – log**	**Exponential co-Efficient**
Constant	43304.857	13.880	14.818	219.573
X1 (Age)	-.871.8	-.004	-.185	-.34225
	(0.83)	(3.21) **	(2.62) ***	(0.68)
X2(Gender)	.150742	.936	-.253	-.64009
	(.000)	(.001)	(.000)	(000)
X3 (Educational level)	-.15486	-.007	-0.78	-.006084
	(.001)	(0.37)	(.31)	(.000)
X4(Martial status)	.3141	.066	.005	.025
	(9.81) ***	(7.77) ***	(9.83) ***	(9.66) ***
X5(Years of experience)	-.50552	-.313	-.925	-.855626
	(.000)	(.004)	(.018)	(.000)
X6 (Access to market)	-.22107	-.137	-.774	-.596754
	(000)	(000)	(.000)	(.000)
X7 (Seasonality)	.3303	.012	-.012	-.000144
	(9.09) ***	(9.56) ***	(9.57) ***	(9.15) ***
X8 (Access to extension agent)	.2440	.014	.023	.0005829
	(8.28) ***	(8.70) ***	(9.46) ***	(8.94) ***
X9 (Household size)	-.1454	.000	.068	.00396
	(3.73) **	(9.70) ***	(3.10) **	(0.96)
X10 (Access to credit)	-.50552	-.313	-.925	-.855626
	(000)	(0.04)	(0.18)	(000)
R^2	.593	.442	.470	.220
Adj R^2	.553	.388	.418	.175
F- Ratio	14.886	8.111	9.047	81.848
Prob > F	.000	.000	.000	.000

Note: figures in parenthesis are't' values, ** significant at 5% level, * highly significant at 1% level**
Source: Computation from field Survey data, 2022.

To ascertain the current amount of income provided by marketing of NTFPs, a multiple regression analysis was carried out. The four functional forms – linear, double-log, semi-log and exponential were used to test. The double logarithmic was chosen since it provided higher number of variables with significance levels and also based on it records of having best R^2, F-ratios and also the best coefficients when signs and significant are considered. The results of the multiple regression analysis are shown in tables 4.3. R^2 indicates the percentages variation in the independent variables. The higher the R^2, the better the equation fits the data.

The four functional form of the model linear, semi-log, double- log and exponential were tested and out of the four functional form, double- log functional form was selected as the lead equation it has the highest significant variables and highest co-efficient of determination R^2 (47%) and F-ratio 9.047. According to the table above, independent variables (age (X_1), (marital status (X_4), (seasonality (X_7), (access to extension agent (X_8) and (household size (X_9) were positively significant. The co-efficient age X_1, marital status X_4, seasonalityX_7, and access to extension agent X_8 were positively correlated with income of NTFPs and were highly significant at 1% while household size X_9 was positively correlated to income of NTFPs marketers and significant at 5%.

SUMMARY, CONCLUSION AND RECOMMENDATION

From the study, it has been observed that marketing of selected non-timber forest product is profitable in Enugu State. These products make direct and indirect contributions to household economy, through the generation of income from the sale of gathered and processed non-timber forest products such *achi*, bush meat, *utazi*, *ukwa*, *ugba*, African bread fruit and numerous others.

However, from the discussion so far in this study, it should be easy to deduce that marketing of non-timber forest project suffers from both governments and policy makers' apathy. Therefore, there is need for improved policy on forest product activities if the government hopes to generate both local and international revenue from this sector. This is because the contributions of this sector would not be made without efficient and effective provision of improved modern forest harvesting/processing technology which will reduce under and over exploitation of the resources. But since some natural forest resources are still in existence, all hope is not lost. There is need to address the concerns of the rural marketers that are involved in non- timber forest marketing. hence these activities add to the economy of the areas.

Based on the above premise and other relevant issues raised in this study, it is therefore considered very necessary that to meet with the demand of the society (concerning non-timber forest product activities), the government and other interested policy makers may find the following recommendation useful.

- The government and other community development organization should regularly host workshops, seminars, and training programs for rural farmers and marketers to increase their understanding of how to preserve and use non-timber forest products and adopt practices for sustainable harvesting.
- The government should provide credit facilities through commercial banks and bank of agriculture to motivate young people in marketing of NTFPs business since it is profitable and sustainable.
- Government should implement good pricing system, relevant laws and harvest guide regulation for sustainability of non- timber forest products, modern storage, processing and preserving facilities should be provided to improve shelf-life, which in turn increase availability of NTFPs after harvest.

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IMPACT OF CLIMATE CHANGE ON FISH PRODUCTION IN NIGERIA (1981-2021)

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ABSTRACT
This study assessed the impact of climate change on fish production in Nigeria. The model made use of time series data spanning from 1981 to 2021. Data on the variables for the study were collected from the archives of Food and Agriculture Organization (FAO) and World Bank database. Data for the study were analyzed using descriptive statistics, Johansen Co-integration test after testing for unit root and Vector Error Correction Model (VECM). The result of Augmented Dickey Fuller (ADF) test for unit root indicated that the variables temperature, rainfall and fish production were found to be integrated of order one and became stationary on first differentiating. The use of Johansen co-integration mechanism indicated that the computed trace statistics (24.66229) is greater than the critical value at 0.05 level (21.13162). The result of the VECM indicated that in the long run, the coefficient of rainfall (5.395) and temperature (-58.523) were statistically significant at 1% which indicated the existence of long run effects of climate change on fish production. In the short run, change in the coefficient of rainfall (0.234) and temperature (0.067) were significant which implies that rainfall and temperature have significant effects on fish production in the short run. The study therefore, recommended that there is need for proper extension services to educate fish farmers on how to mitigate the long-term impact of climate change.

Keywords: *Rainfall, Temperature, Fish Production, Climate Change, Vector Error Correction Model, Augmented Dickey Fuller, Food and Agriculture Organization*

INTRODUCTION
According to the African Partnership Forum (2011), the Intergovernmental Panel on Climate Change (IPCC) has identified climate change as a paramount challenge in the 21st century. Today, climate change stands out as the most pressing global issue, surpassing even the threat of global terrorism (Maduekwe, 2014). Two interconnected challenges facing humanity in this century are human-induced climate change, caused by an increase in greenhouse gas (GHG) concentration in the atmosphere, and agricultural production. Increasing temperatures have led to a surge in extreme weather events, intensifying the impact of climate change (Agba *et al.,* 2017). As climate conditions shift, aquatic life is also affected, leading to potential outbreaks of protein deficiency-related diseases. The agricultural sector bears the brunt of climate change through alterations in rainfall patterns, temperatures, and agro-climatic conditions, which can disrupt growing seasons, water availability, and increase the prevalence of pests and diseases. Moreover, the Niger Delta region of Nigeria experiences acid rains caused by emissions from oil-producing companies, further influencing the type of rainfall in the area (Zievegel *et al*., 2008).

Rainfall is undoubtedly the most significant aspect of climate change in Nigeria and plays a crucial role in determining the country's water resources potential (Lokonon, 2018). The northeast region of Nigeria is experiencing a rapid transition into an arid environment due to a considerable decline in surface water, as well as diminishing flora and fauna resources on land (Obioha, 2008). This consistent reduction in rainfall adversely affects the natural regeneration rate of land resources and contributes to a decline in water levels (Fasona and Omojola, 2005). In contrast, the southern region of Nigeria, known for its high rainfall, is currently facing irregularity in rainfall patterns, and the Guinea Savannah zone in the country is witnessing a gradual increase in temperature. Moreover, the northern zone is under the looming threat of desert encroachment (Federal Ministry

of Environment, 2004). These climatic changes pose significant challenges for various parts of the country and have considerable implications for agriculture, water availability, and overall ecosystem stability.
Disruptions of existing food and water systems will have devastating implications for development and livelihood. These are expected to add to the challenges climate change already poses for poverty eradication (Maduekwe, 2014). According to (Obioha 2009), the sustainability of the environment to provide all life support systems and the materials for fulfilling all developmental aspirations of man and animal is dependent on the suitability of the climate which is undergoing constant changes. The effect of these changes is posing threat to fish production and agricultural output in general within the country. Therefore, there is a necessity to study the impact of climate change on fish production in the country. However, even though climate change is a global phenomenon, the negative impact is unevenly felt depending on the adaptive capacity of individual nations.

METHODOLOGY

Study Area

The research focuses on Nigeria, a country situated on the Gulf of Guinea in West Africa, covering an area of 923,768 square kilometers. As one of the most populous black nations globally, it had an estimated population of around 140 million in 2006 (NPC, 2006). With a population growth rate of 2.6%, the population is projected to be approximately 210.87 million in 2021 (www.statista.com). The country's topography varies, ranging from mangrove swamps along the coast to tropical rainforests and savannah in the north. Its geographical coordinates are approximately between latitude 4°16' and 13°53' north and longitude 2°40' and 14°41' east (Central Intelligence Agency, 2009). Given its highly diverse agro-ecological climate, agriculture plays a crucial role in Nigeria's economy. The climate varies, with the southern region being equatorial, the central area being tropical, and the northern part experiencing a savannah climate.

Data Collection and Analytic Techniques

The research relied on secondary data obtained from the Food and Agriculture Organization (FAO) database covering from 1981 to 2021. The study employed advanced statistical techniques, such as Johansen co-integration, which helps identify long-term relationships among variables. The Augmented Dickey Fuller (ADF) test was used to assess "stationarity" in the time series data, which is essential for conducting meaningful econometric analyses. Lastly, the Vector Error Correction Model (VECM) was employed to examine dynamic relationships between variables and to analyze short-term deviations from long-term equilibrium.

Model Specification

Vector Error Correction Model (VECM)

The study utilized VECM to analyze the causal influence between non-stationary I (1) variables, while also identifying evidence of a long-run relationship among them. The VECM is particularly useful in assessing short-term adjustments that move towards the long-run equilibrium in each time period. When variables are found to be co-integrated, a VECM is estimated because a co-integrating relationship focuses solely on the long-run relationship between variables without considering the short-run dynamics. This approach offers a significant advantage as it enables the determination of both long-run and short-run influences of the endogenous variables in the model. Additionally, it allows the evaluation of the mechanism that maintains the variables in equilibrium.

$$\Delta \ln \mathrm{FIP_t} = \varphi_2 + \sum_{i=1}^{p} \beta_{2i} \Delta \ln RAIN_{t-i} + \sum_{i=1}^{p} \emptyset_{2i} \Delta \ln \mathrm{TEMP}_{t-i} + \sigma_2 + \sigma_2 ECT_{t-i} \dots \dots \dots \dots (1)$$

where: φ *and* σ are mx1 vector of parameters; $\alpha, \beta, \emptyset,$ μ and γ are mx1 and m x p vectors of parameters respectively; p is the optimal lag order that minimizes Information criteria; n is the number of endogenous variables under investigation (rainfall, temperature and fish productivity); ξ_{jt} is an mx1 vector of random variables assumed to be normally distributed white noise process.

RESULTS AND DISCUSSIONS

Unit Root Test

As shown in Table 1, a necessary preliminary test, the Augmented Dickey Fuller (ADF) test for unit root was employed to test whether or not a variable is stationary and also determine the order of integration of the variable. The result indicated that the variables (temperature, rainfall and fish production) were found to be integrated of order one and became stationary on first differencing. This indicates that the variables exhibit random walk (unit roots) or the future values of these variables do not converge from their past values.

Table 1: Results of Augmented Dickey-Fuller (ADF) Test

Variable	ADF	Level			ADF				First Difference
		1%	5%	10%		1%	5%	10%	Inference
Fish Production	0.215	-3.606	-2.937	-2.607	-6.594***	-3.611	-2.939	-2.608	I(1)
Temperature	-2.668	-3.606	-2.937	-2.607	-9.745***	-3.610	-2.939	-2.608	I(1)
Rainfall	-0.224	-3.606	-2.937	-2.607	-6.319***	-3.610	-2.939	-2.608	I(1)

*** Significant at 1%; Source: Data Analysis, 2023

Co-integration Test

According to Engle and Granger (1987) regressing a non-stationary series on another non-stationary series yields spurious regression, but if the linear combination of the series is stationary, we could say the variables are co-integrated and the regression is no longer spurious. Variables are said to be co-integrated if they have long run association. Since the variables are non-stationary, it becomes imperative to test whether or not the variables are co-integrated. Using trace statistics, the result revealed that combination of these variables has one co-integrating equation and this means that linear combination of these variables has a single long run linear combination of relationship or one co-integrating equation.

Table 2: Unrestricted Co-integration Rank Test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.468667	24.66229	21.13162	0.0152
At most 1	0.073737	2.987305	14.2646	0.9476
At most 2	0.00012	0.004677	3.841466	0.9445

Trace test indicates 1 co-integrating equation(s) at the 0.05 level; Source: Data Analysis, 2023.

The results in Table 2 elucidated the computed trace statistics (24.66229) is greater than the critical value at 0.05 level (21.13162). Since the computed trace statistics is greater than the critical value at 0.05 level, therefore, co-integration exists among the variables. This implies that long run relationship exists among climate change (temperature and rainfall) and fish production in Nigeria.

Long Run and Short Run Effects of Climate Change on Fish Production in Nigeria

Given the presence of one co-integrating equation among the variables, indicating a long-run relationship, the study proceeded to estimate the Vector Error Correction Model (VECM). The VECM provides insights into both short-run and long-run effects of rainfall and temperature on fish production in Nigeria. The results of the VECM estimation are presented in Table 3, offering valuable information on how changes in rainfall and temperature impact fish production over different time horizons. The short-run effects provide an understanding of the immediate adjustments that occur in fish production in response to fluctuations in rainfall and temperature. On the other hand, the long-run effects reveal the sustained impacts of changes in these climatic variables on fish production over extended periods.

Table 3: Long and Short-run Effects of Rainfall and Temperature on Fish Production

Long run	Estimates		
Regressors	**CointEq1**		
Fish Prod. (-1)	1.000000		
Rainfall (-1)	5.395 (4.361***)		
Temperature (-1)	-58.523 (-7.757***)		
Constant	213.5959		
Short run	**Estimates**		
ECM	**Fish Prod**	**Rainfall**	**Temperature**
CointEq1	-0.004 (-3.067***)	0.102 (0.236)	0.016 (1.325)
Δ Fish Prod (-1)	-0.281 (-1.333)	0.223 (1.329)	-0.031 (-1.722*)
Δ Fish Prod (-2)	-0.091 (-0.418)	-0.190 (-1.103)	0.018 (0.948)
Δ Rainfall (-1)	0.234 (2.826***)	-0.068 (-0.301)	0.067 (2.755**)
Δ Rainfall (-2)	0.148 (0.584)	-0.172 (-0.856)	0.038 (1.736)
Δ Temperature (-1)	0.742 (0.278)	3.662 (1.726)	0.158 (0.695)
Δ Temperature (-2)	-0.335 (-0.166)	2.288 (1.425)	0.035 (0.202)
Constant	0.052 (2.245)	0.0097 (0.526)	0.0007 (0.392)
R^2	0.567	0.498	0.593
Adj. R^2	0.501	0.337	0.462

F Statistics	3.623	3.086	4.535
Sum sq. residuals	0.285	0.181	0.002
S.E. equation	0.101	0.080	0.009
Mean dependent	0.036	0.006	0.0008
S. D. Dependent	0.096	0.099	0.012

Figures in parentheses are t-values, *significant at 10%, **significant at 5%, ***significant at 1%
Source: Data Analysis, 2023

The result of the VECM indicated that in the long run, the coefficient of rainfall (5.395) was positive and statistically significant at 1%. This implies that a unit increase in rainfall will increase fish production by 5.395 units. This may be due to the fact that increase in rainfall may leads to increase in water availability which encourages fish production. More so, the result showed that in the long run, the coefficient of temperature (-58.523) was negative and statistically significant at 5%. This implies that a unit increase in temperature will decrease fish production by 58.523 units. The result indicated the existence of long run effect of rainfall and temperature on fish production. This gives credence to the finding of Ugwumba *et al.* (2020) who found a positive relationship between rainfall and fish yield in the Anambra River basin.

According to the results of the VECM, in the short run, there is a positive and statistically significant relationship between rainfall and fish production. Specifically, a unit increase in rainfall leads to an increase of approximately 0.234 units in fish production during the first lag period. This suggests that changes in rainfall have an immediate positive impact on fish production in Nigeria, indicating the sensitivity of the fisheries sector to short-term variations in precipitation. It's important to note that the significance at the 1% level indicates a high degree of confidence in the statistical relationship between rainfall and fish production in the short run. These findings can be valuable for policymakers and stakeholders in the fisheries industry to make informed decisions regarding climate adaptation measures and sustainable fisheries management, considering the importance of rainfall in influencing fish productivity in Nigeria. This is in line with Fafiolu *et al.* (2020) found that water temperature was a significant predictor of fish yield in the Ogun River, with higher yields observed during cooler months when temperatures were below 27°C.

The short-run results of the VECM analysis showed that the Error Correction Term (ECT) at lag (-1) is statistically significant and negative (-0.004). The negative sign of the Error Correction Term indicates that there is a tendency for the system to correct deviations from the long-run equilibrium position. In other words, the system is self-correcting when it moves away from the long-run equilibrium.

The magnitude of the Error Correction Term (-0.004) indicates the speed at which the system adjusts back to its long-run equilibrium after a deviation. Specifically, a 0.4% deviation from the equilibrium position is corrected within a year. This implies that the fisheries sector in Nigeria is relatively stable and has a slow adjustment process, with only minor deviations from the long-run equilibrium position being rectified within a short time frame. The significance of the Error Correction Term suggests that there is a strong mechanism driving the system back to its long-run equilibrium, ensuring that any temporary imbalances in the short run are gradually corrected. This information is essential for understanding the dynamic behavior of the fisheries sector in response to climate variables and for developing effective policies and strategies to promote sustainable fish production in Nigeria.

CONCLUSION AND RECOMMENDATIONS

The study investigated the impacts of climate change, specifically focusing on changes in rainfall and temperature on fish production in Nigeria. The study concludes that there is a long-run relationship between rainfall, temperature and fish production in the country. In the short term, fluctuations in rainfall and temperature have a notable impact on fish production, leading to immediate adjustments in fish yields. In the long run, changes in these climate variables continue to exert meaningful and sustained effects on fish production in Nigeria. These conclusions offer valuable insights into the complex interactions between climate change and the fisheries sector in Nigeria. Policymakers, researchers, and stakeholders can utilize these findings to develop effective strategies for climate adaptation, sustainable fisheries management, and enhancing food security in the face of changing climatic conditions.

Based on the findings of this study, the following recommendations were made:

i. There is need for proper extension services to educate fish farmers on how to mitigate the long-term impact of climate change.
ii. It is important to have early warning systems in place to alert fish producers on potential risks of climate change. This could include monitoring weather patterns and ocean conditions, and providing timely information and advice to help stakeholders make informed decisions about their livelihoods.
iii. Given the complex and interconnected nature of climate change and its impact on fish production, it is important to promote collaboration and knowledge sharing among different stakeholders. This could include sharing best practices in sustainable fishing, as well as working together to develop new technologies and approaches to mitigate the impact of climate change on fish production.

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RETIREE'S ENGAGEMENT IN FISHERIES AND AQUACULTURE

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ABSTRACT

Life after retirement becomes a very difficult period for individuals. This literature review looked at retirement plan and engagement of retirees in aquaculture (fish farming) Retiree are expected to have more time at hand for themselves and it is a period for them to rest due to old age. However,, due to some situation of financial disposition that affect retiree at retirement, retiree is expected to engage in one activity or the other in order to earn extra income to complement their pension. It is expected that many retirees are engaged in aquaculture (fish farming) in Nigeria, considering the high demand of fish because of its nutritional value and health benefits to human especially the elderly and because some of our retirees had attended agricultural extension training sessions during their active service.. However, most of them were found out not engaging in fish farming butr other activities. The decision of those who are engaged in aquaculture was influenced by level of education, marital status, household size, personal interest, extension training. The decision of those who were not engaged in fish farming was informed by their age and gender. It is recommended that workers should be trained and encouraged to engage in fish farming after retirement Agricultural extension training programs for workers should be sustained and workers need to be encouraged to engage in fish farming some years prior to their retirement.

Keywords: *Aquaculture, Agricultural Extension Training, Fish Farming, Retirees*.

INTRODUCTION

Good number of retirees return to their villages because of lower cost of living to avoid financial difficulty and high cost of living in urban settlement (Ofuoku, 2012). Those who retire from government and private organization also face some financial constraints on retirement. This is because they are no longer to receive their full salaries and allowances. Retirees do not stay idol however they engage in one activity or the other. Ofuoku (2012) found out that most retirees who embarked on return migration engaged in agriculture and agricultural related activities.

Bur (2001) posits that retirement is the act of leaving one's service either voluntary or compulsorily where such an employee has completed a specified period of service years or is removed from office by way of compulsory retirement, lay-off, dismissal (for acts of insubordination or misconduct), death, illness, disability or by voluntary withdrawal from service.

Rogers (2008) said retirement is a golden time in the life of a worker, where he/she stops working and does the things that he or she had always wanted to do but had never had the time. Thus, for the first time, the individual has the leisure and freedom to travel and do other things of interest freely. Lee and Law (2004) further explained that even the relatively affluent and employees with private pension schemes need to give some attention to this matter, given the increasing proportion of the population that is unable to stay in employment after its mid-50s because of corporate downsizing brought on by the economic recession and slowdown of the global economy. According to Kasschau (as cited in Lee and Law, 2004), a comprehensive retirement planning policy should include all levels of society. He further argues that at the individual level, pre-retirement planning should be the primary responsibility of the individuals so that he or she will have sufficient resources for his or her desired lifestyle and standard of living. At the family level, Kasschau (as cited in Lee and Law, 2004), further posits that because the family is still the main pillar for informal care, individuals should plan and prepare for retirement together with family members.

Fisheries and Aquaculture

Fish is a major source of animal protein and, according to FAO estimates, fish accounted for 17 percent of the global population's intake of animal protein in 2010 (FAO, 2016). In addition to protein, certain micronutrients from animal-source foods, like iron and vitamin A, are more easily absorbed into the body, while vitamin B12 is only available from animal-source foods.

Fisheries and aquaculture sector play a crucial role in food security, nutrition and health, it contributes directly by providing micronutrient- rich fish and other aquatic foods and it indirectly provide a source of full-time, part-time or supplementary income for over 100 million people in fishing, aquaculture operations, processing, trading, retailing and ancillary industries (HLPE, 2014). Local and international fish trade and licenses to access fisheries resources or fees to lease sea areas for aquaculture also provide important contributions to national trade balances and government revenues. Profits from businesses that range in size from household economies to multi-national vertically integrated seafood companies derive business profits from the capture, farming, processing, trading and retailing of fish. These profits in turn contribute to growth and prosperity from local to national levels.

Importance of Fish and fish product

Aquaculture can be defined as the farming and husbandry of aquatic organisms, such as fish, crustaceans, mollusks, and seaweed, and the production of freshwater and marine pearls and a variety of other aquatic species, such as crocodiles, frogs, sponges, and sea cucumbers. (The word "fish," unless otherwise stated, is used throughout in the generic sense to cover all aquatic animal production, including fish, crustaceans, and mollusks). Fish and fish products are known worldwide as a very important diet because of their high nutritive quality and significance in improving human health (Amao *et al*, 2006). Fish plays a vital role in feeding the world's population and contributing significantly to the dietary protein intake of billions of the populace (Amao *et al.*, 2006). On a global scale, almost 16 percent of total average intake of animal protein was attributable to fish in 1988 (FAO, 1990). The Food and Agriculture Organization (FAO, 1991), recommended that an individual takes 35 grams per caput of animal protein per day for sustainable growth and development. Fish contributes 36.6 grams per day of net protein utilization in Nigerian homes (Adekoya, 2004). Fish and fish products provide more than 60% of the total protein intakes in adults especially in the rural areas in Nigeria (Adekoya, 2004).

Fish and fish-related products also provide a primary source of income and livelihood for many communities worldwide, as an estimated 45 million people are directly engaged in the production and harvesting sector. Small-scale fisheries are a key source of employment opportunities and related income. Globally, over 90 percent of those depending on commercial fisheries value chains operate in the small-scale fisheries sector (World Bank, 2012). In addition, secondary sectors such as handling and processing provide employment for millions more. Altogether, it is estimated that fisheries and aquaculture support the livelihoods of some 10 to 12 percent of the world's population (FAO, 2014).

Planning on retirement

Planning for retirement should begin while the individual is still in the middle age; however, persons on the verge of retirement can benefit from planning programs as they learn how to reduce the risk of making poor decisions that may be costly and irreversible (Lee and Law, 2004). Hence, the state has a moral responsibility to educate the public on the importance of retirement planning and to provide resource and planning guides for individuals, groups, and organizations.

According to Lee and Law (2004), planning can be worthwhile and effective only if a person has sufficient resources, knowledge, and the ability both to generate alternative options and take advantage of them in a supportive institutional environment.

Many plans for retirement and start to do something else to earn extra income when they retire from active service. On retirement, the retirees have much time. Hurd and Rohwedder (2003), Ward-Batts (2008) state that before retirees have more available time, they get engaged in more-time intensive production of commodities.

Potentials in fisheries

In Nasarawa State, fish is consumed when roasted, boiled, fried or dried etc. The skin of some cat fish makes useful leather and polishing material; the stem of fish yield substances that when coated are used as glass beads (Iwena, 2008). Fish oil is used for human consumption as well as in the manufacturing of soap. Some species of fishes are used for aesthetic purposes, they are also used for educational and research purposes, Whale fish especially clupeid, anchovy and other species are used for fish meal or condiment (Olaitan and Omomia, 2009). For these reasons, the market and demand for fish is very high and could engage retirees for sustainable livelihood.

Constraints in fisheries activities by Retirees

According to FAO (2004) the challenges that most immediately and directly threaten the sustainability of fisher folk's livelihoods in Africa are poverty, vulnerability and social exclusion. These factors apply not only to fishing communities but generally to the rural poor living in remote areas with little access to social services, infrastructure and markets. According to UN Committee on Social, Economic, and Cultural Rights (2001), poverty is a human condition characterized by sustained or chronic deprivation of the resources, capabilities, choices, security and power necessary for the enjoyment of an adequate standard of living and other civil, cultural, economic, political and social rights. Vulnerability is understood in terms of people's exposure to risks, the sensitivity of their livelihood systems to these risks and limited assets to cope with and adapt to them (UN Committee on Social, Economic, and Cultural Rights (2001)). According to FAO (2004) while poverty and vulnerability are sometimes thought of as end results of a country's policy failures of various kinds, marginalization or social exclusion is conceived as resulting from negative social and power relations with others. The marginalized are excluded from political, social and economic opportunities enjoyed by other citizens.

Constraints experienced by fish farmers, one will not be surprised that many retirees are not involved or engaged in fish farming. This implies that the work force is dominated by the males. However, women also make an encouraging percentage of fish farmers especially in the aspect of fish processing, among the retirees.

Challenges to fishery resources management

Akankali and Jamabo (2011) observed that several empirical evidences existing in literature shows that the fisheries yield from artisanal sources is on the decline in Nigeria. The greatest challenge to fishery is that it is operated by artisans who have learnt the art of fishing informally from their parents.

Most of the fishermen are not educated and can hardly read or write. They lacked modern fishing equipment and can hardly maximize their catch in the face of declining fishery resources, climate and small fishing gears.

Some fish species are fast disappearing and the number of stocks caught is decreasing in average size due to over fishing and other harmful fishing practices. Fishermen use small eyed-nets which catch small and immature fish. The increasing cost of fishing gears in recent times is making it difficult for most fishermen to afford. This increases the cost of fishing in the area.

Etim (2010) attributed the problem of overexploitation to invention and increased sophistication of fishing gear in recent times. The number of fishermen has been increasing while the average catch per week continue to declined, the sizes of individual fish in the catch are also becoming smaller and large sized fishes becoming rare to encounter.

Education as a factor

Level of education was significantly and positively related with retiree's decision on fish farming. The implication is that education is a variable that encourages people to venture into fish farming as Madukwe (1995) states that educational level of farmers is one of the salient variables related to the use of important farm practices. That is how education is also related to the decision by retirees to engage in fish farming. Most retiree should have one level or the other of formal education. Education is expected to be an influencing factor for decision to engage in fish farming after retirement. Education will expose them to useful information on fish farming. Education therefore influences the behavior of retirees' behavior (positive towards fish farming).

Household Size

Marital status will significantly and positively influence the decision of retirees to embark on fish farming. With the responsibility over their spouses their need to earn extra income to cater for the short fall in pension paid to them as pension. Most of retirees have large household sizes. These forms of responsibilities to them as more often than not, most household are dependents. This is in consonance with Ofuoku (2012) who stated that in household size. Household size proved to positively and significantly influence the decision of retirees to engage in fish farming. This means that the larger the household size the more likely a retiree will engage in fish farming activities. This is attributed to the fact that the monthly pension paid cannot adequately cater for the needs of their household members. In order to make up for the reduced income in the name of pension they took the decision to embark on fish farming. Hard and Rohwdder (2003), Ward-Batts (2008) found that retirees have more time available to them and so they shift toward more – time intensive production of commodities.

Retirees and Training

Most retirees should receive extension training in various agricultural enterprises. Ofuoku (2012) suggested extension training for urban – rural migrants most of who are retirees who embarked or return migration to their respective villages. Extension training will have positive and significant influence on the decision of the retirees to embark on fish farming. This implies that the retirees who had extension training tends to be more likely to decide on going into fish farming. Ofuoku (2012) suggest that retirees should be given preretirement years so that they can take to farming after retirement.

Age and Retiree

Age always have a negative but significant relationship with the retiree's decision to get involved in fish farming. This is in consonance with a priority expectation. It implies that older retirees are at risk averse as fish farming is not void of the risk of poaching and the cost of inputs is high. This is congruent with Lemchi *et al*. (2003), Maduakor (2001) who opined that as one becomes older bone becomes more risk averse. This can also be alluded to the fact that sometimes the labor required is intensive.

CONCLUSION

Many retirees find it difficult to make ends meet as a result of reduced income to their households. In order to provide for this shortage in income it is expected that most of them engage in activities that will earn them extra income to supplement the pensions received by them.

Most of the retirees were males and most of them are also married and had one level of formal education or the other. They had average household size of 5 persons and had agricultural extension training. Many retirees were not engaged in fish farming. However, their decision to engage in fish farming was influenced by their gender and age negatively but positively by their level of education, marital status, household size and agricultural extension training they had prior to retirement.

RECOMMENDATIONS

Workers should be encouraged to prepare for retirement by giving them training on fish farming and other agricultural activities.

Retirees should be encouraged to engage in fish farming no matter the level of production, some years before retirement, this will enable them to master the intricacies involved in fish farming so that they can be fully prepared before retirement.

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ASSESSMENT OF FISH HANDLING, PROCESSING AND PRESERVATION IN GUBI DAM, NIGERIA

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ABSTRACT
The study was conducted to investigate fish handling, processing, preservation and socio-demography of fishers in Gubi dam, Nigeria. Structured questionnaire was used for the assessment. The questionnaire was designed to gather information on the management of handling and processing practices which include fish mortality, quality of fish, method of harvesting, fishing gears used, type of fish processing methods, fish storage and duration of fish storage. Percentages were used to analyse the data. Majority of fish processors (73.6%) were males while 26.4% were females. Most (41.5%) of the respondents had primary school education while 11.3% had tertiary education and 18.9% had no formal education. Most (37.6%) of the respondents fell within the ages of 15 – 25. Fishing experiences are mostly (37.7%) within the range of 6-10 years. Most (60.4%) of the fishers were not trained on fish handling techniques while 39.6% were trained. Majority (71.7%) of the gears used in harvesting fish in the dam do not injure the fishes while 28.3% do cause injuries. Daily catches of 60.4% of the fishers is 3 – 4kg with dominant use of scoop net (64.2%). The landed fish were usually in poor hygiene conditions (92.5%) but the post landing handling techniques are generally good (96.2%) with mostly 5 – 6 hours' time of harvesting and handling (43.4%). Fishers in the study area had moderate skills in fish handling and processing techniques. However, such skills can be improved sustainably through regular training such as by fisheries extension workers' services.
Keywords: *Gubi dam, Socio-demography, Fish Handling Techniques, Daily Catches*

INTRODUCTION
Fish is a major and relatively cheap source of animal protein. According to Food and Agricultural Organisation (FAO) in 2010, fish accounted for about 20% of the global population's intake of animal protein (FAO, 2016). Fish is also rich in micronutrients like iron, vitamin A, vitamin B12 and so forth. Globally, more than 90% into commercial fisheries value chains are small-scale ventures with about 45 million people directly engaged in fish production and harvesting sector while secondary sectors such as handling and processing provide employment opportunities and related income for millions more (World Bank, 2012). Fish is one of the protein foods that need careful handling (Eyo, 2002). This is because fish spoils easily after capture due to the high tropical temperature which accelerates the activities of bacteria, enzymes and chemical oxidation of fat in the fish. Due to poor handling of Fish species, about 30 – 50% of fish harvested are wasted in Nigeria (FAO, 2014). These losses could be minimized by the application of proper handling, processing and preservation techniques (Bate and Bendall, 2010).The purpose of processing and handling fish is to get fish to an ultimate consumer in good, usable condition. The fish's gut is a rich source of enzymes that allow the living fish to digest its food (Lima Dos Santos *et al.*, 2011). Fish farmers are faced with the challenges of how to process and handle fish for better consumption as poor quality raw fish produces poor quality end products. Processing can only help to slow down the rate of deterioration. The main aim of this research was to investigate and provide an insight on the activities of fishers and fish processors on the quality assurance of fish caught in Gubi dam through the following objectives: to assess the socio-demographic characteristics of the fishers, fish handling techniques, fish processing and preservation in Gubi dam.

MATERIAL AND METHODS
Study Area
Gubi dam is located at Piro Village, Ganjuwa Local government Area, Bauchi state. The dam is mostly recharged by rivers whose main sources of water are rainfall added water. The rivers are seasonal and dry out during the dry period of the year. it is the largest fresh water body in Bauchi state (latitudes 9° 3' - 12° 3' north and longitudes 8°

50' - 11^0 east). Gubi dam is an earth filled dam with clay core. It has a total storage capacity of 3.84 x $106m^3$. The maximum depth of the dam is 27 meters (m), Length of the embankment is 3.8 kilometres (Km), free board is 3 meters (m) and the spill way is 70 meters (m). The dam has catchment areas of $179km^2$ and reservoir area of 590ha (Anon., 2005).

Data collection

A validated questionnaire was used to gather information from 53 respondents which have been involved in fishing, handling, processing and preservation of fishes caught in Gubi dam. Site inspections were carried out as well for critical observations.

Data Analysis

Descriptive statistics were used in analysing the data with result presented in percentage.

RESULTS AND DISCUSSION

Those surveyed included the fishers, processors, the dry fish producers and the buyers of landed fish. In most instances, an individual may be involved in multiple activities.

Table 1: Socio –Demographic Characteristic of Respondents

Parameters	Percentage (%)
Gender	
Male	73.6
Female	26.4
Level of Education	
Primary	41.5
Secondary	28.3
Tertiary	11.3
None	18.9
Occupation	
Fishing	37.7
Crop Farming	5.7
Crop Farming and Fishing	30.2
Fishing, Crop Farming and Fish Processing	26.4
Age	
15 – 25	37.6
26 – 36	28.3
37 – 50	19.0
51 – 70	15.1

Table 2: Fishing Gears Technology, Hygiene, Catches and Mortality

Parameters	Percentage (%)	Parameters	Percentage (%)	Parameters	Percentage (%)
Fishing gears used in catching Fish		**Injuries to fish due to fishing gears**		**Fish mortality**	
Drag net	20.8	Yes	71.7	10 – 20 fish	50.9
Scoop net	64.2	No	38.3	30 – 40 fish	41.5
Hook and line	3.8	**Exposure to pesticides**		50 – 60 fish	7.6
Cast net	11.3	Yes	92.5	70 – 80 fish	0
Hygienic condition of landed fish		No	7.5	**Time of fish harvesting and handing**	
Yes	7.5	**Adherence to good fish handling techniques.**		1 – 5 hours	15.1
No	92.5	Yes	96.2	3 – 4 hours	32.1
Experience In Fish Handling		No	3.2	5 – 6 hours	43.4
Yes	39.6	**Washing canoe frequently**		7 – 8 hours	9.4
No	60.4	Yes	24.5	**Fishing experience**	
Keeping fish on		No	70.7	1 – 5 years	35.8

floor					
Yes	9.4	**Total weight of fish caught daily**		6 – 10 years	37.7
No	90.6	1 – 2 kg	18.9	11 – 15 years	20.8
Quality assurance (inspection)		3 – 4 kg	60.4	16 – 2 0 years	5.7
Yes	83	5 – 6 kg	15.7		
No	16.6	7 – 8 kg	5.7		

Abdulkarim *et al.*, (2005) investigated fish and fisheries of Gubi dam thereby providing a baseline data. However, the approach of this research in focusing on the socio-demographic characteristics of fishers and on fish handling techniques, processing and preservation is expected to also provide another set of data for future evaluation and monitoring of such fisheries activities in the dam.

Table 3: Fish Processing, Preservation and Handling

Parameters	Percentage (%)	Parameters	Percentage (%)	Parameters	Percentage (%)
Types of fish processed		**Number of years in fish processing**		**Way raw fish are kept before processing**	
Marine fish	0	1 – 5 years	85.7	At room temperature	92.9
Fresh water	100	6 – 10 years	7.2	In a fridge	7.1
Brackish water fish	0	11 – 15 years	7.1	In a freezer	0
The source of raw fish		16 – 20 years	0	**Storage of processed fish**	
Fishers	71.4	**Do you wash hands before processing**		Sold immediately after processing	35.7
Fisher mongers	28.6	Yes	85.7	Refrigerator	0
Cold store	0	No	14.3	Wire mesh (Basket)	42.9
Open market	0	**Materials used to wash hands**		Others	21.4
Others	0	Only water	71.4	**Storage of processed fish before selling**	
Processed Fish Species		Water and soap	14.3	Less than one day	50
Tilapia	57.1	Water and ash	14.3	More than one day Less than one week	42.9
Cat fish	42.9	**How long fish are kept before processing**		One week – 1 Month	7.1
Fish inspection before purchase		Less than 30 minutes	64.3	More than a Month	0
Yes	92.9	30minuts to 1 hour	35.7		
No	7.1	More than one day less than one week	0		
		More than one week	0		

Table 1 elucidates the socio-demographic characteristics of the respondents. Majority (73.6%) were males while 26.4% were females. All the females are in the processing activities as there was no female fisher. Most (41.5%) of the respondents had primary school education; 11.3% had tertiary education while 18.9% had no formal education. This is an indication that new technologies could be easily adapted as just less than 20% of the respondents were not educated more than 80% are enlightened. Although, just 11.3% attended tertiary schools, because others do not have access to further their education due to limited resources and a belief that education has no connection to their income, job opportunities and general success in life. Most (37.7%) engaged only in fishing, followed by 30.2% into both fishing and crop farming and 26.4% were into Fishing, Crop Farming and Fish Processing while few (5.7%) were only into Crop farming. Fishing occupation dominates the society and most (37.6%) of the respondents fell within the ages of 15 – 25 years while few (15.1%) were within 50 – 70 years. These implied that youths dominated the occupation and was observed that most of them inherited it from their fathers and likely that might be the reason which their fishing experiences are mostly within the range of 6-10 years (37.7%) and 1-5 (35.8) as in Table 2. Daily catches of 60.4% of the fishers is 3 – 4kg with dominant use of scoop net (64.2%) which unlike what Emmanuel (2009) opined based on considerable literature review that gill nets is the most important gear used by indigenous fishers followed by long lines and cast nets.The landed fish are usually in poor hygiene conditions (92.5%) but the post landing handling techniques are generally good (96.2%) with mostly 5 – 6 hours' time of harvesting and handling (43.4%).

From Table 3, the hygiene condition of fish and fish handlers were usually assured before purchasing. This hygienic condition of the fish and fish handlers were not satisfactory due to lack of extension services to educate the fish handlers about fish handling and hygienic practice and its importance. Most of the respondent reported that the fish were usually not placed on the ground directly rather they were placed on tarpaulin before sorting the fishes into different species and sizes. The respondent stated that the gears used during fishing does not caused injuries to the fish. The gears used by the fishers were made from simple materials which agree with the baseline study reported by Abdulkarim *et al*., (2005) that the fishing is artisanal small scale in Gubi dam.

CONCLUSION AND RECOMMENDATIONS

Fishers in the study area had moderate skills in fish handling and processing techniques. However, such skills can be improved sustainably through regular training such as by fisheries extension workers' services.

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STOMACH CONTENT ANALYSIS OF *SYNODONTIS SCHALL* FROM OYAN RESERVOIR, OGUN STATE, NIGERIA

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ABSTRACT
The Study of length weight relationship and stomach content analysis of Synodontis schall from Oyan Reservoir, Ogun State was carried out between May and July 2021. Two prominent fishing ground/ landing sites: Ibaro and Apojola were selected for the sampling. 120 specimens of S. schall consisting of fifty- eight (58) male and sixty-two (62) female was examined to determine the length weight and stomach content of the fish. The stomach content analysis using numerical method revealed that S. schall from Oyan dam feed more on phytoplankton and detritus (26.27%) respectively in Apojola and Ibaro landing station. These studies shows that S. schall examined are in good condition and feed very well as the length increases with body weight while most of the stomach content analysed have food materials in them. Majority of the fish examined fed on phytoplankton and detritus due to their benthic feeding characteristics and are carnivorous in nature by feeding on varieties of feed ranging from algae to fish scale. The fishes caught during the research are more of smaller sizes indicating young fishes, further research should be carried out to capture larger fish species.
Keywords: *Stomach content, Synodontis schall, Phytoplankton, Detritus.*

INTRODUCTION
Fishes are sources of food for human beings and other animals, rich in proteins and vitamins, especially, vitamin A (Retinol) (Fayeofori, 2013; Osuigwe and Obiekezie, 2007). It is unfortunate that the protein requirement of most African countries still grossly outweighs its supply (Adakai *et al.,* 2014). In Nigeria, less than 40% of the total protein requirement by the people is met, out of which fish constitutes about 41% (Bernard *et al.,* 2011). The fish Family Mochokidae is one of prominent fish species in Africa and represented mainly by Genus Synodontis commonly referred to as squeaker or upside-down catfish, is widely distributed in African freshwaters ranging from the Nile basin, Chad, Niger and much of the West African region (Paugy and Roberts, 1992). This genus has over 112 species (Daget *et al*., 1991) and some of the species are commercially important comprising up to 40% of the total landings by weight in some regions of Africa (Willoughby, 1974; Sanyanga, 1996) cited by Elias *et al.* 2012. Lowe-McConnell, 1987 reported Synondontis schall (Bloch & Schneider) as the most tolerant species to adverse environmental conditions in the genus and has the widest distribution in Africa. Twenty species of Synodontis species were reportedly found in Northern Nigeria (Reed *et al.*1967) while twenty-one species were identified in Niger (Holden and Reed 1972). The Length Weight Relationship is used in determining condition factor (*k*) is used to compare the "condition", "fatness" or wellbeing of fishes (Seher and Suleyman, 2012). According to Carey and Lawson, 2003, this is based on the hypothesis that heavier fish of a particular length are in a better physiological condition. The food and feeding habit of fish species usually determine the condition and wellbeing of fish as the heavier fish is considered to be in a better condition. The dietary habit of fishes, based on stomach analyses, is widely used in fish ecology as an important method to investigate trophic relationship in aquatic communities (Abdul *et al.* 2016). This study is aimed at providing information on food and feeding habit of *Synodontis schall* from Oyan reservoir as there is paucity of knowledge of this fish species from the reservoir.

MATERIALS AND METHODS
The study was carried out at Oyan reservoir, Ogun State Nigeria. Oyan Reservoir is located at lat. 7°14'N, long. 3°13'E near Abeokuta, the capital city of Ogun State, Nigeria. The reservoir was established in 1984 with, lying adjacent, two resettlement communities named Abule-titun and Ibaro. The dam has an embankment crest length of 1044m, a height of 30.4m, four spillway gates (each 15 m wide and 7m high), and three outlet valves (each 1.8m in diameter). The reservoir has a surface area of 40 km^2, a gross storage capacity of 270 million m3, and a dead storage capacity of 16 million m^3(Ofoezie and Asaolu, 1997).

Samples Collection

A total of One hundred and twenty samples of *S. schall* were collected from local fishermen from two landing sites (Ibaro and Apoojola) in Oyan reservoir. The Total Length (TL) was measured to the nearest 0.1centimetre using measuring board while the Weight (W) was measured into the nearest 0.1g using sensitive scale. The gut of the fish was carefully removed by making a longitudinal incision along the mid ventral line from the mouth to the anus in order to expose the visceral organs. The stomach was later removed carefully by detaching it from other internal organs and fatty tissues. The stomach was removed and immediately preserved in 4% formalin in pre-labeled sterile bottles for subsequent food items examination and analysis in the laboratory. The stomachs were rated 0, ¼, ½, ¾, or full according to their fullness as described by Olatunde (1978). Each stomach sample was opened in the laboratory and the content emptied into a petri dish. The food items were identified using hand lens while others with the aid of light microscope using magnification of X10 and X40 for proper identification. The stomach contents were analyzed using Numerical method.

Numerical Method: Percentage number of a food item

$$= \frac{\text{Total Number of the particular food item}}{\text{Total number of all food items}} \times 100$$

RESULTS AND DISCUSSION

Tables 1 shows different food items recorded in the stomach content of *S.schall* from the two landing sites. Phytoplankton and Detritus accounted for the most occurred food item with 119 items respectively. Unidentified food materials from the two stations were small ranges from 6 to 9 materials. The detritus was the highest food materials recorded in all the month ranges from 78 to119. The lowest food item was the fish scales which range between 48 to 63 food samples.

Table 1: Monthly diet composition of *Synodontis schall* from Oyan reservoir, Ogun State

Month	Blue green algae	Protozoans	Fish scales	Phytoplankton	Detritus	Unidentified materials
May	56	58	48	69	78	7
June	61	60	55	83	95	9
July	81	65	63	119	119	6

The stomach content analyses of *S. schall* from Oyan reservoir using Numerical method was shown in Table 2. This result of stomach content analysis revealed that *S. schall* feeds on various food items such as Blue green algae, protozoans, fish scales, phytoplankton and detritus. Some unidentified food item was also recorded in small quantity.

Table 2: Stomach content analysis of *Synodontis schall* from Oyan reservoir, Ogun State (Numerical method %)

Month	Blue green algae	Protozoans	Fish scales	Phytoplankton	Detritus	Unidentified materials
May	17.72	18.35	15.19	21.84	24.68	2.22
June	16.80	16.53	15.15	22.87	26.17	2.48
July	17.88	14.35	13.91	26.27	26.27	1.32

DISCUSSION

The food items recorded from stomach content analysis of *S. schall* were Blue green algae, protozoans, fish scales, phytoplankton, detritus and unidentified food items. The phytoplankton and detritus accounted for the highest food item of 26.27% respectively using Numerical method of stomach content analysis. Unidentified food item recorded the least with 1.32% of the food item. Fish scales also have the lowest percentage of 13.91%, this is in line with lowest percentage of it recorded by Elias *et al.* 2012 in Lake Chamo and this shows the carnivorous feeding habit of the fish. The varieties of food items found in stomach content of *S. schall* shows the omnivorous feeding habits of this genus as reported by Shinkafi *et al.*(2010). Feeding on larger percentage of detritus indicate a demersal or bottom feeding characteristics of the genus Synodontis as reported by Shinkafi *et al.* (2010).

CONCLUSION

The stomach content of *Synodontis schall* in Oyan reservoir, Ogun State showed that the fish species is an omnivorous feeder indicated by the verse varieties of food items found in their stomach.

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TECHNOECONOMIC ANALYSIS OF TILAPIA (*OREOCHROMIS NILOTICUS*) FISH CONVECTIVE DRYING

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ABSTRACT.
The effect of pre-treatment on the drying behavior of Tilapia (Oreochromis niloticus) fish was investigated. (pre-treatment at 0 min, 5 min and 10 min steam blanching respectively) In addition, the economic analysis of the optimal drying period of Tilapia fish in consequence to applied pre-treatment was studied. Results showed that the drying behavior of samples occurred at a single falling rate period signifying a heat and moisture permissible microstructure of the fish. The drying time for 0, 5- and 10-min steam blanched samples were 750, 630 and 570 min, respectively. The economic metrics showed that the commercialization of 10 min steam blanched convectively dried Tilapia fish has a payback period of two and half years within ten years maximum operational period of the drier. The results can assist citizen's capacity development, empowerment and food security.
Keywords: *Tilapia fish, drying, pretreatment, economic, convective, food*

INTRODUCTION

Tilapia (*Oreochromis niloticus*) fish is a freshwater fish species that belongs to the Cichlidae family (Lee *et al.*, 2014). It is a popular fish species worldwide due to its high nutritional value, fast growth rate, high productivity and adaptability to different environmental conditions (Adeyi *et al.*, 2022). Tilapia fish also have high protein content and several medicinal usefulness, which makes it an excellent dietary source of protein for humans (Mahbub *et al.*, 2019).

Tilapia fish like other foods, is perishable and therefore need processing for preservation and storage. Amongst processing methods, drying is simple, effective, and economical. Drying increases product acceptability, shelf life, concentrate protein content and add market values. Traditionally, open sun drying is one of the most commonly utilized methods to preserve Tilapia fish (Lee *et al.*, 2014), however, the inconsistency, and unhygienic characteristics of open sun drying makes it unacceptable in the modern times. Nowadays, drying technologies such as solar or solar tunnel, convective oven, freezer, infra-red, microwave, amongst others have emerged. Amongst the many emergent drying technologies, convective dryer is technically fulfilling for commercial purposes (Adeyi *et al.*, 2022).

A notable challenge of convective oven drying is the long drying time; however, literature has it that this challenge could be significantly handled if adequate pretreatment methods such as blanching were applied (Adeyi *et al.*, 2022). It is important to minimize agro produces' drying time to lower energy utilization for process sustainability, products' economic production and environmental preservation, products' undesirable fermentation and dried products' quality preservation.

Furthermore, most research outputs are usually not implementable due to dearth of knowledge about its commercialization economic implications. Economic analysis helps in determining the cost drivers of the drying process (Fudholi *et al*., 2016). By conducting an economic analysis, such as for drying process, investors can make informed decisions and take steps to improve the overall efficiency and profitability of operations (Poonia *et al*., 2017).

Therefore, the aim of this study is to conduct a techno-economic analysis of Tilapia fish drying through the following specific objectives: (1) investigate the effect of steam blanching as pretreatment on the drying time of Tilapia fish, and (2) conduct economic analysis of the Tilapia fish drying process based on least drying time.

MATERIALS AND METHODS

Fresh *Oreochromis niloticus* Tilapia fishes (harvested on the same market day) were purchased from Waso market in Ogbomoso Oyo State Nigeria. The fishes were degutted, de-scale and washed with potable water. The prepared

fishes were air-dried at room temperature prior to drying in Stangas (SG-9052G, Stangas Luxury Modern Appliances, Italy) convective dryer.
The Stangas convective dryer is equipped with temperature regulator, 3000 W heating element, fan and vent. Digital weighing balance (0.01 g accuracy) was utilized for measurement purposes. Tuneable heater (1000 Watts) was utilized for heating during sample pretreatment.

Pre-treatment procedure

Samples of Tilapia fish (100 g each) were cut out from the fleshy part of the fish for steam blanched. The first sample was steam blanched by exposure to steam from Tuneable heater with the aid of expanded wire mesh for 5 min in the laboratory in accordance with the method of Taiwo and Adeyemi (2009). The second sample was also steam blanched in the same way for 10 min. After blanching, the samples were allowed to air dry and attain room temperature. Thereafter, the samples were subjected to drying.

Drying Procedure

The contribution of steam blanching pre-treatments to the drying time of Tilapia fish was determined. The pre-treated Tilapia fish were dried in the Stangas convective oven at nutritive quality preserving temperatures of 70 ^{O}C, and at a constant dryer air velocity of 2.0 m/s. The ambient air temperature varied between 29 and 31 ^{O}C. The dryer was allowed to operate for 30 min prior to insertion of the pre-treated sample. The instantaneous weights of the sample undergoing drying were determined at reasonable intervals (10 min at the drying onset, 20 min at mid drying times and 30 min at later drying times). This was achieved by discontinuously weighing the sample on digital weighing balance and repeated severally until a constant sample weight was observed (Adeyi *et al*., 2022). Drying experiments were done in replicates for the purpose of data integrity, and the mean of the replicates were used to describe the drying characteristics and time of the pre-treated Tilapia fish samples. The initial moisture content of fresh Tilapia fish used in this study was 241.3 % d.b as determined by oven drying method at 105 ºC for 24 h in accordance with the report of Kaveh *et al*, (2021). Equations 1 – 2 assisted in empirical drying data analysis.

$$M_a(d.b) = \frac{W_F - W_D}{W_D} \text{ X } 100\% \quad (1)$$

Where M_a = initial moisture content in percentage dry basis (%), W_F = fresh weight of the sample (g) and W_D = dried weight of the sample (g)

$$MR = \frac{M_t - M_e}{M_a - M_e} \quad (2)$$

Where, MR is the moisture ratio, M_t = moisture content at a given time t during drying (g of water/g of dry matter) and M_e = final equilibrium moisture content (g of water/g of dry mater).

Economic Analysis

Financial consideration to assist potential investor take decision on commercialization of Tilapia fish drying was investigated. Usually, conducting economic analysis starts from market research where information is gathered regarding the demand for the intended product in the targeted market, understanding the preferences, purchasing behavior, and potential competitors for the intended product. Thereafter, a cost analysis that includes all aspect of production is undertaken with particular interest in drying procedure that results in least drying time with the assistance of Eqn. (3) - (8).

$$\text{Energy consumption} = \text{dryer power} * \text{drying time} \quad (3)$$

$$\text{Cost of fresh fish per batch} = \text{fresh fish per batch} * \text{Cost of fresh fish per kg} \quad (4)$$

$$\text{Cost of electricity used} = \text{dryer power} * \text{drying time} * \text{cost of electricity} \quad (5)$$

$$\text{Revenue per batch} = \text{dried weight} * \text{selling price per kg of dried fish} \quad (6)$$

$$\text{Net income per batch} = \text{Revenue per batch} - (\text{Electricity cost} + \text{Labor cost} + \text{Maintenance cost} + \text{wet weight cost}) \quad (7)$$

$$\text{Payback period} = \text{Initial investment on dryer} \div \text{Net income per batch} \quad (8)$$

RESULTS AND DISCUSSION

Effect of blanching on drying characteristics

The effect of pretreatment (un-blanched, 5- and 10-min steam blanching) on moisture removal profile and drying time of Tilapia fish in this study is represented in Fig. 1. The three represented profiles showed a single drying falling rate period. This represents a non-reluctant drying rate which can be related to the permeable microstructure of the sample. The unblanched sample showed the longest drying time of 750 min, followed by the 5 min steam blanched sample (630 min drying time) and 10 min steam blanched sample (570 min drying time). These showed that steam blanching reduced drying time as blanching time increased.
The point of deflection from the steep slop signifies a point moisture removal reluctance. This is related to change in texture or case hardening phenomenon in the sample. The last points of the profiles signify equilibrium stage where the samples have low/safe moisture content that is required for storage and shelf stability. Taiwo and Adeyemi (2009) observed a similar result.

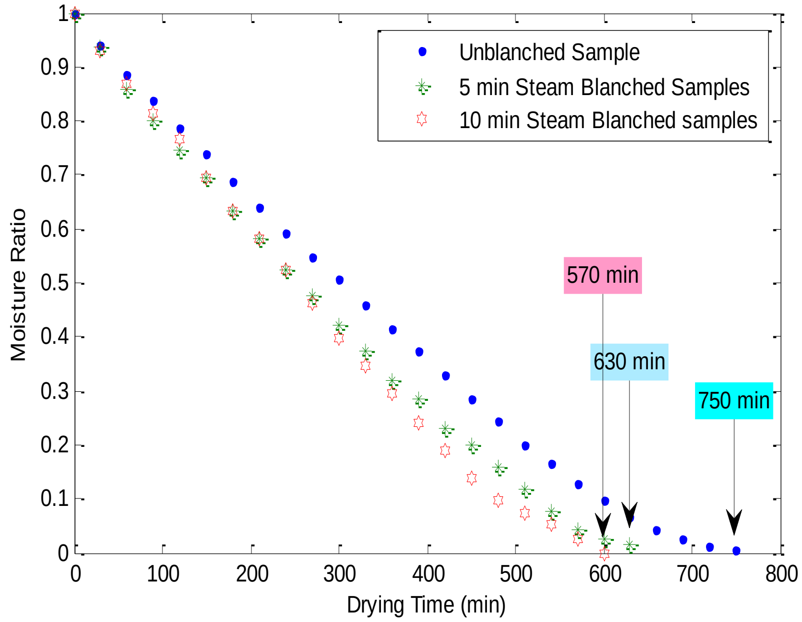

Fig 1. Drying profile of Tilapia fish in convective oven

Economic metric

The economic analysis of Tilapia fish drying (steam blanched at 10 min) is represented in Table 1. The 10 min steam blanching was utilized because of its lowest drying time).

Table 1 Table of economic analysis

Parameters	Amount	Unit
Dryer cost	100000	1
pcs		
Dryer capacity	50	kg
Fresh fish/batch	50	kg
Dried fish/batch	16.5	kg
Dryer power	3	kW
Drying time	12	hr
Number of batches in a year	52	
Batch		
Cost of electricity per kWh	26	₦
Cost of labor/batch	1000	₦
Cost of dryer maintenance/batch	100	₦
Selling price/kg of dried fish	3200	₦
Cost of fresh fish/kg	1000	₦
Energy consumption	36	
kWh		
Cost of fresh fish per/batch	50000	₦
Cost of electricity used	936	₦
Revenue/batch	52800	₦
Net income/batch	764	₦
Payback period	130.89	
Batch		
Number of year equivalent of Payback period	2.51	
Years		

The assumptions used includes unchanging price of fresh Tilapia fish, constant availability of fish, electricity, demand for dried Tilapia fish, labor cost, and dryer maintenance cost for 5 years. Therefore, sensitivity analysis was not necessary. Furthermore, the tax or other government levies that might affect the cost or benefit of the project are ignored, and that inflation rate will be zero for the five-year analysis-covering period.

The results showed that the revenue per batch is significantly higher than production cost, which is desirable. At this revenue per batch, results showed that the payback period for the initial investment is about two and half years, which is also desirable. It therefore means that the rest of eight and half years will be for gain making. Therefore, the business is worthwhile.

CONCLUSION

In this study, the effect of steam blanched pre-treatment on drying time of Tilapia fish was undertaken. In addition, economics metrics of the drying process consequent to pretreatment was investigated. The results implied that increment in steam blanching time reduced the drying time significantly. This was attributed to increased tissue loosening as a result of steam blanching. The economic analysis with reasonable assumptions and in connection with present market prices showed that 10 min steam blanched plus convectively dried Tilapia fish hold a profitable commercial potential. It is concluded that the results of this study can aid citizen's capacity development, economic empowerment, and thus contribute to food security.

RECOMMENDATION

It is recommended that a similar study of Tilapia drying should be replicated using a smoking kiln instead of the electrically powered convective dryer due to the erratic nature of electricity in Nigeria.

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EFFECTS OF DIFFERENT SMOKING SOURCES ON QUALITY CHARACTERISTICS OF AFRICAN CATFISH (*CLARIAS GARIEPINUS*)

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ABSTRACT
The study was conducted to investigate the organoleptic characteristic and polycyclic aromatic hydrocarbon in smoked eviscerated catfish using four different energy source of wood charcoal: Gmelina (Gmnelina arborea), Parkia (Parkia biglobosa), Neem (Azadirachita indica) and charcoal from commercial market in Ogbomoso (mixture of different wood types). Overall acceptability was based on 5-point Hedonic scale (excellent (5) -poor (1). Chemical test was on Polycyclic Aromatic Hydrocarbon (PAH) contents (benzo (α) pyrene, Fluoranthene, Napthalene, Acenapthalene, Benzo (k) pyrene). Smoked fish sample produced with Parkia and Neem had higher mean scores for overall acceptability followed by charcoal and Gmelina respectively. Smoked catfish samples produced with charcoal had the lowest level benzo (α) pyrene followed by Neem, Gmelina, and Parkia. The concentration is within the EC'S recommended maximum limit of 5µ/kg for benzo (α) pyrene which has been classified as carcinogens. Conclusively, it can be drawn that fish produced by charcoal among other sources investigated is the best and most suitable for human consumption.
Keywords: *Cat fish, Smoked fish, wood sources, organoleptic characteristic*

INTRODUCTION
Fish is one of the most important sources of animal protein available in the tropics and has been widely accepted as a good source of protein and other elements for the maintenance of healthy body (Andrew, 2001). There are various reasons that trigger smoking and preservation of fish, chief of which is its high susceptibility to deterioration without any preservative or processing measures (Okonta and Ekelemu, 2005). Soon after death, fish begins to spoil. In the healthy live fish, all the complex biochemical reactions are balanced, and the fish flesh is sterile. After death, however, irreversible changes that results in fish spoilage begins to occur. The resultant effect is the decomposition of the fish (Akinola *et al.,* 2006; Singh and Heldman, 2013; Pigott, 2015).
A considerable effort has been directed to extend the shelf life of fish using preservation and processing techniques, such as refrigeration, freezing, canning, salting, drying and smoking (Okonta and Ekelemu, 2005; Singh and Heldman, 2013; Pigott, 2015, Davies and Davies, 2005). Smoking is the preferred cheap method to preventing fish spoilage. This is carried out-over smoldering wood, sawdust or other local source of energy using traditional kilns constructed with locally sourced materials. All these methods have the effect of imparting pleasant flavour to the product beside the preservative effect of the smoke itself (Burgress *et al*., 1965; Tull, 1997). This experiment aims to evaluate the effect of different types of energy sources on organoleptic properties and polycyclic aromatic hydrocarbons (PAHs) composition on smoked African catfish.

MATERIALS AND METHODS
Experimental Procedure
A total of hundred (100) table size African catfish *Clarias gariepinus* were obtained from a reputable fish farm in Ogbomoso. The modern smoking process (using charcoal oven) experiment was carried out at the fishery unit, Ladoke Akintola University of Technology (LAUTECH) Teaching and Research Farm, Ogbomoso. African catfish samples were eviscerated washed with clean water and smoked using four different fuel sources Beachwood *(Gmelina arborea*), African locust bean tree *(Parkia biglobosa*), Neem (*Azadirachita indica*) and charcoal.
The fish were smoked to complete dryness and the time taken for complete dryness was recorded (state the time) using a digital stopwacth, the smoking temperature for all treatments was maintained between 80^0C and 100^0C. The time taken for fish to be smoked using the Gmelina, Parkia, Neem and charcoal smoked fish was 8 hours,

6.5 hours, 7 hours and 5 hours, respectively. The smoked samples were kept at room temperature after complete dryness and about 5g samples for each treatment were taken to the laboratory for analysis.

Organoleptic Test

The smoked fish samples were assessment based on scoring system by Emokpae (1979) which involved measurement of certain parameters on a 5-point hedonic scale (excellent (5), very good (4), good (3), fair (2) and poor (1) for colour, texture, taste, flavour and overall acceptability.

Chemical Analysis

Smoked fish samples were analyzed for Polycyclic Aromatic Hydrocarbon PAHsBenzo(α)pyrene, Fluoranthene, Napthalene, Acanapthalene, Benzo(k)pyrene) according to the methods of the proximate composition of the wet and smoked fish were analyzed for proximate composition according to the method of A.O.A C (2000).

Statistical Analysis

Data collected were subjected to one way analysis of variance (ANOVA) using general linear model (GLM) of factorial experiment design and means were separated by Duncan's multiple index (P< 0.05).

RESULTS

Table 1: Sensory score for Smoked Catfish (*Clarias gariepinus*) using four different sources of Energy in ogbomosho.

Parameters	GSS	Judgement	PSS	Judgement	NSS	Judgement	CSS	Judgement
Colour	3.90	Light	3.36	Light	2.81	Dark	4.63	Light
Flavour	2.93	Medium	2.54	Medium	2.81	Edium	2.27	Medium
Taste	2.54	Medium firm	3.54	Medium firm	3.27	Medium firm	2.27	Delicate
Texture	3.27	Good	3.54	Very good	4.09	Very good	3.09	Good
Acceptability	2.88	Acceptable	3.25	Acceptable	3.25	Acceptable	3.07	Acceptable

GSS : Gmelina smoked sample; PSS: Parkia smoked sample; NSS: Neem smoked sample;
CSS: Charcoal smoked sample. Judgement based on hedonic scale

Table 2: Polycyclic Aromatic Hydrocarbons concentration in smoked Catfish (*C. gariepinus*) using four different sources of Energy

Parameters	GSS	PSS	NSS	CSS	SEM
Benzo(ghi)pyrene (µg/kg)	0.76^{a}	0.69a	0.12b	0.67^{b}	0.11
Acenaphthylene (µg/kg)	0.74^{a}	0.68^{a}	0.73^{a}	0.31^{a}	0.08
Phenanthrene (µg/kg)	1.24^{a}	1.72^{a}	0.17^{b}	0.05^{b}	0.18
Chrysene (µg/kg)	2.70^{b}	2.71^{b}	0.72^{a}	0.31^{a}	0.34
Pyrene (µg/kg)	1.92^{b}	1.86^{b}	0.23^{a}	0.18^{a}	0.26
Benzo(α)pyrene (µg/kg)	2.74^{a}	2.75^{a}	0.73^{a}	0.32^{b}	0.34
Fluoranthene (µg/kg)	2.04^{a}	2.19^{b}	0.25^{b}	0.19^{b}	0.33
Naphthalene (µg/kg)	2.89^{a}	3.83^{a}	0.83^{b}	0.79^{b}	0.46
ΣPAH(µg/kg)	15.25^{c}	11.91^{b}	2.27^{a}	2.19^{a}	1.75

GSS: Gmelina smoked sample; PSS: Parkia smoked sample; NSS: Neem smoked sample;
CSS: Charcoal smoked sample.

Sensory Evaluation

African catfish samples produced using Charcoal as smoke source had higher average score for colour (4.63) than other samples. Charcoal smoked samples had a bright appearance and conform to consumers' preference for smoked fish. Smoked catfish samples produced with Neem and Parkia woods had a medium firm texture compared with other samples. Average scores of texture for smoked samples produced Gmelina, Parkia and Neem wood were 2.63, 2.54, 2.81 and 2.27 respectively. Fish samples produced by the four smoke sources; Gmelina, Parkia, Neem and Charcoal had organoleptic characteristics which appeals to consumers preference.

PAHs Concentrations

Benzo(α)pyrene (BαP) concentrations in charcoal samples was lower than other treatments. There was significant difference (p<0.05) in the concentration of BαP present in samples smoked using other smoke sources. Values of BαP in Charcoal wood-smoked catfish samples was significantly (p<0.05) low at 0.32µg\kg compared to other samples of Neem (0.34µg\kg), Gmelina (2.74µg\kg) and Parkia (2.75µg\kg)

Total PAHs concentration present in smoked African catfish samples was higher in samples produced with Gmelina (15.25µg\kg) than other treatments. However, total PAHs concentration found in Charcoal (2.19µg\kg) produced smoked fish was significantly ($P<0.05$) lower than others.

DISCUSSION

Organoleptic evaluation score for charcoal smoked Fish was higher than others in colour (4.63), taste (3.82) and acceptability (3.27) other samples.

Generally, all fish samples processed using Charcoal smoke recorded less PAHs. This may be due to the short drying time as a result of the high heat and less smoke produced by Gmelina. This is consistent with the findings of Silva *et al*., (2011), who observed in their study that at high temperatures, less smoke was produced and at lower temperatures, more smoke was produced during the smoking process. The results of concentrations of total PAHs in smoked African catfish samples presented in table 2 revealed that all the samples dried using Gmelina wood as smoke sources recorded the highest levels 15.25 µg/kg followed by the samples dried using Parkia and Neem with total PAHs content of 11.91 µg/kg to 2.27µg/kg respectively. The samples dried using Charcoal as smoke source recorded the lowest total PAHs concentration (2.19µg/kg). The trend of the concentrations of the total PAHs of the fish from high to low based on the processing methods is presented in the following order: Gmelina>Parkia >Neem> Charcoal. This is in agreement with Moret *et al.,* (1997) postulation that the actual levels of PAHs in smoked foods depend on several variables in the smoking process, including type of smoke generator, combustion temperature, and degree of smoking.

CONCLUSION

The results of this study revealed that eviscerated African catfish samples smoked using Gmelina had the highest concentrations of PAHs followed by Parkia, Neem and charcoal. Although for a sustainable fuel source, charcoal smoking produced the healthiest smoked fish product in terms of PAHs contamination. Benzo (α)pyrene concentrations of 0.32µg/kg and 0.37µg/kg respectively were detected in the smoked fish samples produced with Neem and Charcoal. These levels are within the European Commission (2006) regulatory limit of 5µg/kg. This indicates reduced consumer health risks associated with using charcoal in smoking fish.

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DIETARY EFFECTS OF *FICUS EXASPERATA* (SANDPAPER LEAF) ON THE GROWTH PERFORMANCE AND EGG PRODUCTION OF AFRICAN CATFISH (*CLARIAS GARIEPINUS*, BURCHELL 1822)

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ABSTRACT
Ficus exasperata leaf is a terrestrial afro-tropical shrub found to containing nutrients such as protein, carbohydrate, fiber, vitamins, carotenoids and minerals which are essential for growth. This occurrence suggested the investigation of the effect of F. exasperata leaf on growth performance and egg production when included in the diet of Clarias gariepinus. Leaves of F. exasperata were plucked, air dried for four weeks, blended and stored in airtight dry bags. Proximate composition of blended leaves revealed that F. exasperata leaf is high in crude protein (21.35%). The blend was used to formulate diets at varying inclusions which was used to feed the experimental fishes. Five treatments namely T1 (0.00g inclusion/100g), T2 (0.02g inclusion/100g), T3 (0.03g inclusion/100g), T4 (0.04g inclusion/100g), and T5 (0.05g inclusion/100g) were created and duplicated in a complete randomized design. Feeding trial revealed that treatment four (T4, 0.04g/100g of feed) had the highest level of growth performance parameters for Final Mean weight (FMW), Mean Weight Gain (MWG), Percentage Mean Weight Gain (PMWG), Specific Growth Rate (SGR) and Protein Efficiency Ratio (PER). T4 was significantly different to T1 at p<0.05. Highest egg parameter (EW= Eggs Weight, EN= Egg Number, EV= Egg Volume) values were observed in treatment five (T5, 0.05g/100g of feed), showing significant increase in the parameters more than other treatments, with values significantly different at p<0.05. Hence, it is recommended that F. exasperata leaf at 0.04g/100g inclusion in the diet of C. gariepinus gives optimum growth performance as well as egg production and can be adopted by fish farmers as well as feed millers.
Keywords: *Clarias gariepinus, Ficus exasperata, growth performance, egg production.*

INTRODUCTION
Many scientific studies revealed that leafy vegetables are good sources of nutrients such as protein, carbohydrate, fiber, vitamins, carotenoids and minerals which are essential for growth (Afolabi *et al*., 2012). The presence of secondary metabolites such as Steroids, polyphenols, flavonoids, phlobatannins, tannins, saponins and in appreciable levels in plant leaves could contribute to their medicinal properties (Oulai *et al*,. 2014).
Ficus exasperata leaf is found to be natural delicacy to goats and other ruminants in south western Nigeria, among the yorubas (Weladji *et al*., 2004). *F. exasperata* have also been proven to be medically useful in the treatment of many health disorders (Bafor *et al*., 2009; Sonibare *et al*., 2006). Adebayo *et al*., (2009), stated that the presence of steroids, flavonoids, phlobatannins, tannins and saponins, give the leaves, stem back and roots of *F. exasperata* the pharmacological qualities.
This work therefore aimed at investigating the level of nutritive elements in the leaves of *F. exasperata*, the effects this leaf may have on growth performance of *Clarias gariepinus* (Burchell 1822) when included at varying levels in the diet and the effects on egg production and parameters.

MATERIALS AND METHODS
Experimental Site
Research was conducted at Fisheries and Aquaculture unit of Ladoke Akintola University of Technology, Teaching and Research Farm, Ogbomoso, Oyo state, Nigeria.
Experimental Fish
One hundred and fifty (150) *Clarias gariepinus* (400g to 500g) were procured from a reputable farm and acclimatized for two weeks while been fed extruded feed twice daily (7.00hrs and 16 .00hrs).

Collection of Experimental Leaves (*Ficus exasperate)*

Healthy leaves of *Ficus exasperata* were obtained from Ladoke Akintola University of Technology Teaching and Research Farm demonstration plots and were further identified at the Department Pure and Applied Biology of the university. Samples were air-dried at room temperature (27.5 ± 2.6^{0}C) for a period of 4 weeks and were regularly turned to ensure homogeneous drying. Samples were blended into powder form and kept in dry air-tight bags.

Proximate Analysis

The proximate composition of *Ficus exasperata* leaves were determined according to the method of Association of Official Analytical Chemists (A.O.A.C, 2002)

Formulation of Experimental Diet

Feed ingredients namely; maize, wheat offal, groundnut cake, fishmeal, soybean meal, vegetable oil, oyster shell, bone meal, salt, methionine and lysine were purchased from a reputable feed mill in Ogbomoso. Five (35% CP) diets containing varying levels (0g, 0.02g, 0.03g, 0.04g and 0.05g inclusions) of *F. exasperata* powder were formulated. Feeding trials were conducted for twelve weeks.

Experimental Set-up

Experimental design was complete randomized design (CRD). There were five treatments of *Ficus exasperata*, namely; control diet 1 (0g), diet 2 (0.02g), diet 3 (0.03g), diet 4 (0.04g) and diet 5 (0.05g) per 100g of feed. Each treatment was duplicated and seven healthy juvenile were assign to each experimental unit.

Determination of Growth Parameters

Fish weight changes and feed intake data were monitored and documented. Mean Weight Gain (MWG), Percentage Weight Gain (PWG), Specific Growth Rate (SGR), Feed Conversion Ratio (FCR), Protein Intake (PI) and Protein Efficiency Ratio (PER) parameters were calculated from the data collected using the mathematical relations below.

- MWG= Final Mean Wt – Initial Mean Wt
- PMW =(Mean Wt gain/Initial Mean Wt)*100
- SGR = (Log FMW – Log IMW/No of days)*100
- FCR = Feed Intake/MWG
- PI = Feed Consume * %CP in Feed
- PER = MWG/PI

Eggs Collection

The oval egg sacs were excised and kept in 10% formalin prior to the analysis. Egg Parameters observed were Egg volume, Egg weight and Egg number.

Statistical Analysis

One way analysis of variance (ANOVA) was used to analyze data collected. Means were separated by Duncan's multiple range test (Duncan 2020).

RESULTS AND DISCUSSION

Table1: Proximate Composition of *F. Exasperata* Leaf

Proximate Constituents	DM	MC	ASH	CFT	CF	CP
(%)	92.50	7.50	16.20	3.30	11.40	21.35

DM= Dry Matter; MC= Moisture Content; CFT = Crude fat; CF= Crude Fibre; CP= Crude Protein.

Proximate analysis of *F. exasperate* on in Table 1 revealed that dry matter content was highest at 92.50%, followed by crude protein content 21.35%, ash content 16.20%, crude fibre content 11.40%, moisture content 7.50% and crude fat 3.30%. The result showed that leaf of *F. exasperata* is rich in crude protein, a constituent of interest while formulating feed for *Clarias gariepinus* with crude protein requirement range of 30% to 40% (Tadesse, 2019).

Craig and Helfrich (2002) also stated that crude protein level in aquaculture feeds generally are within average 35% to 40% for African catfish.

Table 2: Growth performance of *C. gariepinus* fed with varying inclusion levels of *F. exasperata*

Parameters	T1 (Control)	T2 (0.02g)	T3 (0.03g)	T4 (0.04g)	T5 (0.05g)	SEM
IMW (g)	223.15	223.86	223.65	223.29	223.72	1.48
FMW (g)	321.79^{b}	341.13^{b}	347.18^{a}	359.19^{a}	339.96^{a}	3.81
MWG (g)	98.65^{b}	117.27^{ab}	123.54^{a}	135.90^{a}	116.22^{ab}	3.43
PMWG(%)	44.31^{c}	55.92^{ab}	54.78^{ab}	60.73^{a}	50.15^{bc}	1.56
SGR(%/day)	0.16^{c}	0.20^{ab}	0.19^{ab}	0.21^{a}	0.18^{bc}	0.00
FCR	2.48^{a}	2.10^{b}	2.21^{ab}	2.05^{b}	2.41^{a}	0.05
FI(g)	229.26^{b}	246.36^{b}	269.63^{a}	273.78^{a}	278.93^{a}	4.31
PI(g)	80.24^{b}	86.21^{b}	94.37^{a}	95.83^{a}	97.63^{a}	1.51
PER	1.21^{bc}	1.37^{ab}	1.31^{abc}	1.42^{a}	1.19^{c}	0.27

All the parameters with different superscript are significantly different ($p<0.05$)

IMW= Initial Mean weight; FMW=Final Mean Weight; MWG= Mean Weight Gain; PMWG= Percentage Mean Weight Gain; SGR= Specific Growth Rate; FCR=Feed Conversion Ratio; FI = Feed Intake; PI= Protein Intake; PER=Protein Efficiency Ratio; SEM= Standard Error of Mean.

Table 2 revealed that highest Final mean weight, Mean weight gain, Percentage mean weight gain, Specific growth rate and Protein efficiency ratio were observed in treatment 4 (0.04g/100g) while the lowest Final mean weight, Percentage mean weight gain, Specific growth rate were observed in treatment 1 (0.01g/100g). The eventual decrease in the values of the parameters listed above and observable in treatment 5 may be an indication that a further increase in the inclusion of *F. exasperata* above 0.04g/100g will be limiting to growth performance of *Clarias gariepinus* juveniles.

The results on table 2 also showed significant differences at $p<0.05$ between values of treatment 4 (0.04g/100g) and treatment 1 (0.00g/100g) for mean weight gain, percentage mean weight gain, specific growth rate and protein efficiency ratio.

Table 3: Effect of *F. exasperata* leaves on egg parameters of *C. gariepinus*

PARAMETERS	T1(0g)	T2(0.02g)	T3(0.03g)	T4(0.04g)	T5(0.05g)	SEM
EW	53.49^{b}	26.43^{c}	62.25^{ab}	67.88^{ab}	78.66^{a}	4.05
EN	39128.02^{b}	19335.40^{c}	45536.57^{ab}	49658.97^{ab}	57545.30^{a}	2960.00
EV(m/s)	605.50^{a}	362.00^{b}	639.50^{a}	646.50^{a}	699.50^{a}	29.53

Parameters with different superscripts are significantly different at $P< 0.05$
EW= Eggs Weight, EN= Egg Number, EV= Egg Volume

The highest values of egg weight, egg number and egg volume were observed in treatment 5 (0.05g/100g), while the lowest values of egg weight, egg number and egg volume were observed in treatment 2 (0.02g/100g). There is an observable increase in the values of parameters from treatment 2 (0.002g/100g) with increase in the amount of *F. exasperata* inclusion per 100g. Further increase in inclusion per 100g may yield noticeable increase in egg weight, egg number and egg volume. There are also significant differences between values of parameters in treatment 5 and treatments 1 and 2, however there is no observable significant difference at $p<0.05$ in egg volume for treatments 1 and 5.

CONCLUSION

The results obtained in this study revealed that, inclusion of 0.04g/100g *F. exasperata* leaf (treatment 4) in the diet of *C. gariepinus* had the best growth performance in terms of MWG(Mean Weight Gain) and PER (Protein Efficiency Ratio) as well as an optimal utilization and conversion of feed into flesh and muscles.

Egg quality parameters were observed to have optimal results at 0.05g/100g inclusion level. Therefore, it can be concluded that 0.04g *F. exasperata* leaf-based diet can be included in the diet of African catfish (*C. gariepinus*) to enhance a better growth performance and egg production.

RECOMMENDATION

Based on the findings of this research, *F. exasperata* leaf at 0.04g/100g inclusion in the diet of *C. gariepinus* gives optimum growth performance as well as egg production. Therefore it is recommended that fish farmers and feed mill owners can adopt the use of sandpaper leaf meal (*F. exasperata*) in fish diet at the recommended level.

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ANALYSIS OF FACTORS INFLUENCING CATFISH PRODUCTION IN NSUKKA LOCAL GOVERNMENT AREA OF ENUGU STATE, NIGERIA

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ABSTRACT
This study analysis the factors influencing catfish production in Nsukka Local Government Area of Enugu State. The primary data were obtained using structured questionnaire from 120 catfish producers. Descriptive statistics such as frequency distribution, percentages and multiple regression analysis were used to analyzed the data. Majority (73.7%) of the catfish farmers were within the economically active age (30-59 years) and will contribute significantly to catfish production, 58.3% having more than 5 years of production experience. Most (93.7%) of the respondents had primary education, 62.5% of the sampled farmers had family sizes of more than 5 persons. The majority (78.0%) of the respondents do not belong to cooperative societies and 1001- 2000m² pond size mostly used by the respondents. Education of the farmers, production experience, feed used, stock density and labour used were the factors that positively and significantly influenced catfish production in the study area. Catfish producers should pay special attention to the identified factors to boost production.
Keywords: *Factors, Catfish production, Nsukka, Area*

INTRODUCTION
Fish farming is the fastest-growing animal husbandry industry in Nigeria and many parts of the world. In most parts of Africa, the most cultured species is Tilapia and Catfish. In Nigeria, the demand for fish is 2.66 million metric tones and only 1.4 million metric tones is available of which the country imports over 500 000 mt annually. Therefore, the importance of the fishing industry to the sustainability of animal protein supply in the country cannot be over-emphasized.
Regrettably, the supply of fish (an essential food) has been on the decline. This is due to consistent declines from the country's major source of fish supply, the artisanal fisheries, from 90% in 1990 (Tobor, 1990) down to 40% in 2006 resulting to about 300,000 metric tonnes (Global Agriculture Information Network (GAIN), 2007). Currently, domestic fish production is put at 551,700 metric tonnes as against the present national demand of about 1.5 million metric tonnes estimated for 2007 (Osawe, 2007). The shortfall is said to be bridged by the importation of 680,000 metric tonnes annually consuming about N 50 billion in foreign exchange (Odukwe, 2007). To close the gap existing between the demand and supply of fish in Nigeria, catfish farming should be encouraged. Adediran (2002) and Ugwumba (2005) asserted that the only way of boosting fish production and thereby move the country towards self sufficiency in fish production is to boost catfish production. Traditional fish farming practices have been prevalent in the study area. Farmers fish on natural bodies and this led to a problem of decline in the catch per unit effort. Greater improvement in catfish production can be achieved with a proper analysis of the factors that influence catfish production.

METHODOLOGY
This research was carried out in Nsukka Local Government Area of Enugu State. It has an area of 1,810 km² and a population of 309,633 at the 2006 census. Nsukka Local Government Area comprises nine communities which are Alor, Iheakpu-Awka, Eha- Alumona, Edem, Opi, Nsukka, Lejja, Obimo and Ibagwa. The Local Government Headquarters is located in the hilly and green sites which Nsukka is known for close to colonial quarters of the pre-Independence years. The era is bordered in the east by Ede- Oballa, in the west by Obino, in the north by Aku and in the south by Enugu-Ezike and Uzo-Uwani. Nsukka Local Government Area occupies an area of 1810km² It is located between latitude North of the Equator and longitude 7^0 39' and 7 ^{0}99' East of the Greenwich Meridian (www.nimet/nsukka.org). The people are mostly farmers who take advantage of the rich and abundant farm land to engage in both crop production and animal husbandry. Many people engage in animal husbandry which includes: piggery, fishery and rearing of cattle. Others cultivate yam, rice, cassava, cereals and vegetables, among

others. Others engage in trading and skill work such as wood work, mat weaving, basket weaving and blacksmithing. Data was generated from respondents by the use of structured questionnaire and oral interview. Multistage random sampling technique was used to select communities, villages and respondents. First, four (4) communities in the study area were randomly selected from six (6) autonomous communities. Secondly, three (3) villages were randomly selected from each of the selected communities. Lastly ten (10) catfish farmers were randomly selected from each of the selected villages to make a total of one hundred and twenty(120) respondents for detailed study. Descriptive statistical tools such as frequency tables, mean and percentages was used to analyze the socioeconomic characteristics of respondents. Gross margin analysis was used to estimate the cost and returns of catfish farming. Multiple regression analysis was used to determine the effect of socio-economic characteristics of farmers on their output. The multiple regression model is stated thus: $Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, ei)$

The four functional forms of the model are explicitly specified as follows:

Liner: $Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + ei$.

Semi-log: $Y = \text{In}b_0 + b_1\ln X_1 + b_2\ln X_2 + b_3\ln X_3 + b_4\ln X_4 + b_5\ln X_5 + b_6\ln X_6 + b_7X_7 + ei$

Double- log: $\text{In}Y = \text{In}b_0 + b_1\ln X_1 + b_2\ln X_2 + b_3\ln X_3 + b_4\ln X_4 + b_5\ln X_5 + b_6\ln X_6 + b_7X_7 + ei$

Exponential: $\text{In}Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + ei$.

Where Y= Catfish Output (kg), bo = intercept, b_1-b_6 = Coefficient to be estimated, X_1 = Age of the famer (years), X_2 = Stock Density (number of fish in pond), X_3 = Educational level (years spent in formal education), X_4 = Fish farming experience (years), X_5 = Feed used (Kg), X_6 = Labour (Mandays), ei = error term.

RESULTS AND DISCUSSION

The socio-economic characteristics of the respondents such as: age, gender, level of education, marital status, household size, membership of association, pond size and farming experience are presented in Table 1 below.

Table 1: Distribution of respondents according to socioeconomic characteristics

Variable	Frequency	Percentage
Age		
20 -29	16	13.3
30 -39	18	15
40 -49	70	58.3
50 -59	8	6.7
60 and above	8	6.7
Education level		
No formal	8	6.7
Primary	17	14.2
Secondary	51	42.5
Tertiary	44	36.6
Production experience		
1 -5	50	41.7
6 -10	42	35.6
11 -15	15	10.0
Above 15	16	13.3
Household size		
1 -5	56	46.67
6 -10	58	48.33
11 and above	6	5.0
Membership of Association		
Yes	42	35.0
No	78	65.0
Source of working Capital		
Formal sources	48	40.0
Informal sources	72	60.0
Pond size		
100 – 1000M^2	36	30.00
1001 – 2000M^2	58	48.33

2001 – 3000M^2	26	21.67

Source: Field data, 2021

Result in Table 1 revealed that majority (73.3%) of the respondents were within the age bracket of 30-49 years, implying that most of them are within the economically active population and therefore constitute a good labour force for fishery enterprise. Amazon et al (2000) indicated that farmers in their active age would be good managers of limited available resources. Most of the respondents acquired formal education. Only 6.7% of the total respondents had no formal education. This education attributes of the respondents will help extension agents in effective dissemination of innovations to the farmers. Educated individuals are usually innovative, adaptive and prudent in resource use. Majority (58.3%) of catfish farmers had more than 5 years production experience, which is good enough to understand the production techniques. This is in line with apriori expectation, the more years of experience a farmer has, the ability to overcome challenges of production as well makes them be willing to adopt improved technologies that would earn a better profit. About 53.33% of the respondents had more than 5 persons in their household.. This result reveals that the Catfish farmers household size is relatively moderate. Household size is a principal determinant of labour availability in small- scale farming system given the relatively soaring cost of hired labour (Nwosu et al 2012). Majority (65%) of the respondents had no contact with extension agents. This implies that many catfish producers in this study area do not participate in any new innovation disseminated by the agricultural extension agents. It could be also as a result of inaccessible roads in the study area that hinders entrance of the agents. Only 35% of the respondents obtained capital from formal sources (banks, Governments programmes , etc. This implies that majority of the farmers relied on informal sources . Majority of the farmers avoided borrowing from the banks because of the high interest rate charged by the banks as well as the demand for collateral. According to Balogun (2011) inadequate access to credit facilities is a major problem limiting large scale agricultural production and marketing activities. Pond size of 1001 - 2000m^2 was mostly used by most of the farmers. What matters most is the stock density, to ensure that fish are not congested in the pond and there is adequate space for their growth.

Table 2: Regression estimates of the determinants of Catfish output in the study area

Variable	Linear	Exponential	Double log+	Semi- log
Constant	0.465 (-11.844)***	-0.328 (-4.624)***	0.240 (10.968)***	2.958 (4.411)***
Age	-4.835 (-0.989)	0.081 (3.990)	0.012 (3.355)	0.314 (2.914)***
Stock Density	-0.092 (-2.002)**	0.012 (-0.876)	0.045 (-2.008)**	0.051 (-2.018)
Edu. level	6.467 (3.476)***	2.921 (2.646)**	0.094 (2.489)**	0.745 (10.206)***
Production Experience	0.183 (2.263)**	0.004 (5.044)***	0.134 (3.632)***	0.534 (0.707)***
Feed used	079 (1.973)	-0.024 (-1.459)	0.138 (3.498)***	0.571 (9.164)***
Labour	134 (2.926)	-0.001 (-2.404)	-0.003 (3.000)***	-0.035 (-0.583)
R^2	0.733	0.763	0.772	0.672
F-value	54.299***	61.516***	38.175***	102.908***

Source: Field survey 2019

* = significant at 10%. **= significant at 5%. *** = significant at 1%.

Figures in parentheses are t – values

Table 2 shows result of multiple regression on the determinants of catfish production

The four functional forms of linear, exponential, semi-log and double log were tried. Cobb Douglas production function was chosen as the lead equation because of the higher number of significant variables and highest value of coefficient of determination (R^2) and also agreement with a priori expectation. The R^2 value of 0.772indicates that 77% of the variation in the output of catfish was explained by the independent variables considered in the model. The F- value was 38. 175 and significant at 1% probability level indicating that the model gave a good fit. The coefficient of age was negative and significant at 5% probability level. This is consonance with a priori expectation. Nwane reported that the risk bearing ability, innovativeness of farmers and even his mental ability decreases with advancing age. The coefficient of stock density was positive at 5% probability level. This is in line with a priori expectation. Fish ponds should be appropriately stocked to avoid over-crowding. Lagos State Agricultural Development Agency (LSADA, 2005) recommended 1000 juveniles per 10 x 10 M ^{2} pond.

Education level was positively signed and statistically significant at 5% alpha level. Result is in line with a priori expectation. The higher the educational level of the farmer the higher will be the production, ceteris paribus. This result is in consonance with Anozie et al (2014) who reported that, the higher the educational attainment the efficient the person is in resource use and less risk averse and more readily innovation are adopted. The coefficient of production experience was positive and significant at 1%. Years of farming experience helps to enhance farmers capacity of maximizing their farm output and profit at minimum cost.

The coefficient of feed used was positive and statistically significant at 1% level. This implies that any increase in quantity of feed used by the catfish farmers will increase quantity of catfish produced while any decrease in feed used will lead to reverse. This is in line with the a priori expectation since a well fed fish will grow faster, be presentable and marketable. Ebukiba and Luka (2019) stressed the importance of feeding fish adequately and with quality feed for good returns. Labour used was another significant variable at 1% level of probability and have positive sign. This implies that the amount of labour applied in farming determines the quantity of output produced. This could be the reason for low production for the small holder farmers when compared to the large scale or commercial farmer who can afford and employ skilled workers.

CONCLUSION AND RECOMMENDATIONS

Based on the findings of this research it may be concluded that: Age of the producers, their educational level, production experience, stock density and feed used were the factors that significantly affect catfish production in the study area. Also the following recommendations were proffered based on the research findings: Catfish producers should pay special attention to the identified factors. They are encouraged to form cooperative societies. Cooperatives are important in capacity building, acquisition of credit and procurement of quality production inputs at subsidized rates.

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SUSTAINABLE AQUACULTURE: AN ALTERNATIVE SOURCE OF ANIMAL PROTEIN IN NIGERIA

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ABSTRACT

The review evaluates the current state of Fish production in Nigeria, particularly aquaculture, challenges to aquaculture development and provides solution to them. It assesses the current fish demand which stands at 3.61 million Metric tons while the supply stands at 1.84 million and production from Aquaculture stands at 350,000 MT. The production from this sector has consistently grown over the years, the largest aquaculture producer in Sub-Saharan Africa. The paper highlighted the progressive development of Aquaculture from its inception in 1949 and various government efforts that culminated to improved production of aquaculture. The paper further highlighted some of the challenges of aquaculture production which includes high cost of fish feed, inadequate supply of high quality fingerlings, poor data for planning and high cost of energy. It stated the role climate change has on fish breeding And production as well as poor marketing system. Several remedies were provided for these challenges highlighted. They included the replacement of fish meal which had hitherto been a limiting factor with insect meal and cassava leaf concentrate at varying inclusion levels. On the inadequate fingerling supply, it noted the there is need for improved hatchery management which include the use of live food, introduction of 3% salt solution in the rearing facility of the hatchery, which serves as anti-stress as well as maintaining good temperature. It ended by recommending the use of solar energy to replace fossil fuel to reduce energy cost as well as training and retraining of farmer, particularly on farm record keeping.
Keywords: *Fish production, aquaculture, solar energy, fossil fuel*

FISH DAMAND, SUPPLY AND POTENTIAL

Nigeria has a population of about 200 million people providing a large market for fish. Fish plays a significant role in human diet, well being and commerce of many growing economies. It is a good source of animal protein and income in many countries. In Nigeria, fisheries sub sector contributed 0.88 % to the Agriculture GDP and contribution of Agriculture to Nigeria GDP is 22% (FDF, 2018). FDF 2018 also stated that the sub-sector provides employment for 8.632m million people in the primary sector and 19.55 million people in the secondary sector. Agricultural production is the generally enhanced through genetic improvement and this generally lead to improved varieties (Megbowon *et al*., 2009) Fish demand stood at about 3.61 million MT while supply is about (FDF, 2018). The Fisheries sub-sector provides job for 8.632 million people in the primary sector and 19.55 million people in the secondary sector (Giwa *et al*., 2018). Nigeria has an estimated annual per capital fish consumption of 17.5 kg (FAO, 2018). Fish demand stood at about 3.61 million MT while supply is about 1.84 million MT and production from Aquaculture was 350,000MT in 2018 (FDF, 2018). In 2020, Nigeria was the second largest producer of Aquaculture in Africa (FAO,2020) and it is a well-known fact that aquaculture is one of the world's leading food production sectors globally (Megbowon *et al*., 2013).

Fish production in Nigeria comes basically from artisanal fisheries obtained from inland rivers, lakes, coastaland brackish water, industrial fishing and Aquaculture. The bulk of fish production comes from capture and artisanal fisheries. In 2015, the gross domestic production was 1.027million metric tons. The artisanal fishery alone contributed about 67.7% (694,867.00 MT); aquaculture contributed 30.8% (316,727.00 Metric tons) while industrial fishery contributed 1.5 % (15,464.00) (Giwa *et al.,* 2018) Table 1 shows the trend of fish production by sectors and export from 2006-2015. The table reveals the inconsistency in the production from artisanal and industrial sectors making the sectors unreliable in driving fish production. Fish farming continues to develop in techniques as well as operation and and utilization of inputs, even though there is high cost and scarcity of such inputs they are affecting the overall development of fish farming. The table equally shows consistent growth of the aquaculture sector. This has been the trend in recent times, indicating that aquaculture sector is the most

reliable sector to improve domestic fish production. Several fish species are available in Nigeria. They include mud catfishes (*Clarias* spp.), Tilapias snake head (*Channa* spp.*)* head, slap water (*Heterotis niloticus*), trunk fish (*Gymnarchus niloticus*), Marine fishes such as Niger perch (*Lates niloticus*), Bonga (*Ethmalosa fimbriata*), Croakers (*Pseudotholitus* spp.), grunter *(Pomadasys jubelini*), barracuda (*Sphyraena barracuda*) among others.
Nigeria has consistently depended on importation of fish to meet the rising fish demand. It was reported that Nigeria is a net importer of fish and fishery products (FAO, 2013). A number of government interventions were made to implement policies that are capable of bridging the gap between demand and supply of fish and fishery products in Nigeria. Aquaculture has made tremendous impact in recent time to scale up Nigeria's domestic fish production. It has grown from 84,533 MT in 2006 to 316,727.00 MT in 2015, making Nigeria the largest aquaculture producer in Sub-Saharan Africa. This should make the nation to do everything possible to improve aquaculture development. The table 1 shows the data of fish production by sector.

Table 1: Data of Fish Production by Sector from 2006 to 2015 the table should cover a ten or five year period from 2019 to date or 2017 2022 as the case may be.

YEAR	Artisanal Production (MT)	Industrial Production (MT)	Aquaculture Production (MT)	Total Domestic Prod. (MT)	Fish Import (MT)	Total Fish supply (MT)	Fish Export (MT)
2006	518,538	33,778	84,533	636,848	646,484	1,283,332	7,738
2007	504,227	26,193	85,087	615,507	739,666	1,355,173	5,136
2008	511,382	29,986	143,208	684,575	937,427	1,622,002	5,355
2009	598,221	29,698	152,796	780,705	746,851	1,527,556	4,761
2010	616,981	31,510	200,535	849,026	768,745	1,617,771	4,049
2011	638,486	33,485	221,128	893,099	762,508	1,655,607	4,377
2012	668,754	45,631	253,898	698,283	758,619	1,726,902	3,967
2013	744,930	59,871	278,706	1,083,507	770,802	1,854,309	4,619
2014	759,828	49,952	313,231	1,123,011	776,552	1,899,563	4,577
2015	684,867	15,464	316,727	1,027,057	806,000	1,833,058	4,256

Source: FDF (2018).
There is great potentials in fish culture Nigeria Inland due to Water Surface Area of 14 million hectares available for cage culture, Available land for Aquaculture, put at 1.7 million hectares and Estimated Aquaculture Potential of 2.5 million MT,

TREND OF AQUACULTURE DEVELOPMENT IN NIGERIA

The culture of fish in Nigeria began in 1949 at Onikan, Lagos, Nigeria, as a small experimental system, with tilapia as the cultured fish (Longhurst, 1961). The interest in fish farming led to the construction of Panyam Fish located in Plateau state of the North central Nigeria in 1951 with interest in the common carp, *Cyprinus carpio* (Anetakhai, *et al.*, 2004). Between 1951 and 1971, fish farming continued to expand, being dominated by the Governments, both at state and Federal level. This implies that governments and their agencies were involved in direct production of fish. From 1971-1981, government established demonstration farms in Agodi, Ibadan (South West), Okigwe, Itu and Opobo (South East) and Mando, Kaduna State (North west). Other efforts at promoting fish farming in the country included the establishment of fish seed centres across the country by Federal and State governments in addition to the establishment of the African Regional Aquaculture Centre, assisted by Food and Agriculture Organization at Aluu, Portharcourt, River state. The Centre was to serve as research support and training of middle class fisheries officers .From 1981-1991 government stimulated efforts in developing fish farming led to private sector participation. Between 1991 and 2010 it became apparent that fish farming should be seen as a business. During this period, Agriculture Development project which was supported by the World bank came into existence. During the period the formation of Fish farming cooperatives and cooperative Estates brought about rapid development in the industry. For instance, Eriwe Village fish farm estate started in 2003 with 30 fish farmers, has grown to over 1,500 farmers, providing job for over 3,000 persons by 2020. Each farmer allocated 2 ponds (0.02 Ha), stocking at 15-20 fish/m^2. A group of 20 fish farmer formed a cooperative in the scheme. Purchases of input, construction of ponds and sales of fish are centralized where funding could be sourced through cooperative loan at 18% P.A In the scheme, earthen ponds were used. Similar to these is the Ikorodu fish farm Estate, using concrete tanks,.These models has facilitated rapid development in the industry in Ogun and Lagos States and Should be replicated across the region

CHALLENGES OF AQUACULTURE IN NIGERIA AND REMEDIES

The culture of fish is bedeviled by a number of challenges. These include high cost of feed. Feed constitutes 75% of operating cost of fish culture. While some producers depend on imported feed which is not sustainable, other rely on local feed. However, the limiting ingredient in this feed is fishmeal which is often imported. It is generally assumed that catfish require High Crude protein of 40% and above but experience has shown that 30-35% is adequate (Mohanta *et al*., 2023), thus reducing cost. Furthermore there is need to explore local sources of protein which can replace fishmeal and close alternatives is insect meal. Studies were conducted on other alternatives to fishmeal which are more ecofriendly. They include; Cassava leaf concentrate (45% CP), Black soldier fly meal; *Hermatia illicens (*47% CP*)*, mopane larvae meal; *Imbrasia belina* (56% CP), grasshopper*; Gastrimargus acrinidae (*62% CP*)*, Rhinoceros beetle larvae; *Orectyes rhinoceros (*51% CP) and poultry processing waste and blood meal.

Another major setback for catfish farming is inadequate seed production. For sustainable production of fish there must be steady supply of good quality fingerlings on regular basis. This has however been hampered by a number of factors such as poor quality broodstock due to inbreeding depression, inadequate live food and locally produced fry feed to reduce cost, heavy mortality during growing process (Matthews-Mbokane *et al*., 2022). On this there are 2 schools of thought. Some believes that mortality is due to feed while others attribute this to Climate change, global temperature rising, taking its toll on catfish breeding. To ameliorate this there is need to develop broodstock bank. This is because the quality of the broodstock determines the quality of the fingerlings. Similarly, it must be understood that breeding is a 24/7 business operation. It should equally be borne in mind that the rearing medium should have 3% salt solution to reduce stress and lower water temperature (Wurts, 1995). We need to equally explore vigorously production of live foods like Moina and Daphnia as alternative to artemia to reduce cost and ensure survival as the larvae grow better and have better survival on live food (Das *et al*., 2021).

Another critical challenge faced by farmer is power. Electricity has been a major problem in Nigeria for tank rearing of fish. Public electricity supply is rarely available where fish farms are located in the rural areas. Framers therefore have to rely on alternative power source, by generating the required energy themselves using fossil fuel. The cost of fossil fuel, particularly diesel, is very high, thus affecting cost of production and profit. To overcome this, farmers may need to resort to the use of solar energy for sustainability. Other solution includes the rearing of fingerlings to about 200 g and transfer to earthen for fattening. Furthermore, where there are large expanse of water, fish could be cultured in cages as this does not require water exchange as seen in pond or tank culture. It may be necessary to increase the scale of operation to 100 tons per annum to enhance economy of scale where farmers need to rely on fossil fuel.

Others include non-availability of data for planning. Most farmers don't keep farm record, thus making planning and government's intervention difficult. Another problem is that of fish marketing which makes middle men take advantage to exploit the farmers due to unorganized market structure. Formation of farmers into cooperative society will go a long way to enable farmers to negotiate price better. Farmers can as well go to value addition in order to increase profitability.

CONCLUSION

The potential of fish farming in Nigeria is high but production at the moment is lower than expected. The data available are not reliable for effective planning because farmers are not keeping records. No country ever developed without research. Government need to provide adequate funds for Aquaculture research to facilitate service delivery. The challenges of Aquaculture are surmountable if appropriate mechanism is put in place to address them.

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EFFECTS OF PHYTOBIOTICS POWDER ON INNATE IMMUNE RESPONSE OF *CLARIAS GARIEPINUS* JUVENILES

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ABSTRACT
Phytobiotics are plant based compounds that promote growth, improve the innate immune system and overall productivity of fish. The beneficial effects of Phytobiotic powders; moringa leaf, ginger, garlic and a combination of the three, as well as a control diet without additives on innate immune gene expression of Clarias gariepinus juveniles were investigated in this study. Significant differences in the expression level of immune gene have been identified between the phytobiotics fed supplements and the control diet. Furthermore, differential gene expression analysis revealed upregulation of TNF-α gene expression in fish fed with a control fish-fed diet (no Phytobiotics fed supplements) having a fold change of 1.436 ± 0.791. However, the innate immune gene TNF-α was observed to be downregulated in Clarias gariepinus fed with Phytobiotics supplements of garlic, ginger, moringa based diets and a combination of all having a fold change of; 0.288 ± 0.088, 0.196 ± 0.145, 0.124 ± 0.034 and 0.097 ± 0.30 respectively. These results revealed that the fish fed phytobiotics leaf-based diet compromised the action of the innate immune gene TNF-α, despite being shown to have phytochemical properties improving fish health while the upregulation observed in fish fed with the control diet presumes there is a significant expression of TNF-α which is advantageous in pathogen resistance.
Keywords: *Phytobiotics, immunity, gene expression, Clarias gariepinus*

INTRODUCTION
Phytochemicals are natural plant dietary supplementation in aquafeed which could be used as an effective way for increasing growth and the immune-competency of fish. Most common phytochemicals are Moringa (*Moringa oleifera*), Garlic (*Allium sativum*) and Ginger (*Zingiber officinale*) which are both perennial crops, natural, readily available, affordable and have been reported to promote various health activities (Wahab *et al*., 2022). Moringa leaves, fruits, barks and roots have high nutritive value and possess immunostimulant, anti-inflammatory, antiulcer, antibacterial, hypoglycemic, antihypertensive, and hepatoprotective properties (Kazeem *et al.*, 2017). According to Abayomi *et al.* (2018), garlic contains variety of bioactive compounds and phytochemicals such as flavonoid, saponins, alkaloids and allicin. Nutritional and phytochemical analyses revealed that garlic contains about 17 amino acids, 33 sulphur compounds, several enzymes, minerals and vitamins. Ginger has been reported to be rich in mineral elements, vitamins, and phytochemicals which have a high anti-inflammatory and antioxidant effect (Iheanacho *et al.*, 2017).
Results have suggested that *M. oleifera* leaf powder-supplemented diets could enhance the immune response of *Oreochromis niloticus* fry and prevent disease caused by *A. hydrophila* (El-Gawad *et al*., 2020). Dietary inclusion effect of ginger and garlic have also been shown to induce growth in *Clarias gariepienus* (Nyadjeu *et al*., 2021) and feed formulated with these supplements fed to Common carp has shown significant increase in RBCs, WBCs, PCV, Hb and total plasma protein (Ajeel, and Al-Faragi, 2013). Feed supplements used in feed formulation having anti-oxidative and inflammatory active components triggering inflammatory response is of an advantage to Fish immune system. Cytokines are commonly thought to play a role in the creation of immunological and inflammatory responses. One of these cytokines is Tumor Necrosis Factor Alpha (TNF-α), which is involved in innate immune response in Fish.
Understanding the interaction between fish nutrients and its immune system are critical for the new product development to increase aquaculture production efficiency; hence necessitated this study.

MATERIALS AND METHODS

Fish Tissue Sample Collection

The experimental fish were divided into five groups (4 representing fish fed phytobiotic leaf-based diet and 1 control) and were fed twice a day with 2% phytobiotic diets inclusion. Fish tissue samples were collected from each group after feeding trial which lasted for Ten weeks. In the molecular Biology Laboratory Nigerian Institute for Oceanography and Marine Research (NIOMR), tissues samples (1 g) were collected from the ventral region Cordero *et al*. (2017) of *Clarias gariepinus* and immersed in 1 ml of RNALater buffer, contained in well labeled 2 ml Eppendorf tube to maintain RNA stability, and stored in the Refrigerator at -20° C until further use.

RNA extraction, cDNA synthesis and PCR amplification

Total RNA was isolated using JENA mini kit (Jena Bioscience, Germany) according to the manufacturer's protocol. The purity and concentration of RNA extract was determined using a Thermofisher 1000 C Nanodrop spectrophotometer. Reverse Transcription Polymerase Chain Reaction (RtPCR) was carried out using Fire script RT cDNA synthesis kits (FIREScript®, Estonia, using Oligo dt primer with the thermal profile: 65˚ C for 5 mins for denaturation, followed by Primer annealing at 25˚ C for 10 mins and 85˚ C for 5 min to inactivate RT enzyme). The housekeeping Gene, Glyceradehyde 3 Phosphate dehydrogenase (GAPDH) and the immunity gene, tumor necrosis factor alpha (TNF-α) were used to quantify the complementary DNA (Primer sequence shown in Table 1), amplification was done with initial denaturation at 2 min at 94ºC followed by 30 cycles of the following; denaturation at 94ºC for 30s, annealing at 54ºC for 30s and extension at 72ºC for 30s.

Table 1: Primers used for Nucleic acid qualification in this study

Primer	Forward Sequence	Reverse Sequence	Tm (°C)	Band Size (pb)
GAPDH	GCCCTCTGGTAAAATGTGGA	ATTCCCTTCATGGGTCCTTC	54	450
TNF-α	GGATGGTGGTGTGTGTTGTG	CTGGTACTCTGGTCACGACTC	60	150

Data Analysis

GraphPad Prism software 20.1 was used to carry out one-way analysis of variance (ANOVA) to test for significant differences ($p < 0.05$) among fed treatment groups and control and data were presented as mean ±SD.

RESULTS AND DISCUSSIONS

Recently, research findings suggested phytobiotics as potential antimicrobial agents having bioactive compounds to stimulate immunity and fish resistance against diseases unlike antibiotics that sometimes have potential negative effect on the fish produced, the consumer and the environment when used by fish farmers in fish health management (Zulhisyam *et al*., 2022). In the current study, the quantified cDNA gel capture (Figure 1) shows GAPDH PCR amplicons on 2% agarose gel electrophoresis of reverse transcribed RNA sample. The gel band suggests the presence of TNF- α (immunity) gene in all the treatment groups indicating that the immunity gene is expressed in them all at different levels. The expression of the TNF-α gene was upregulated in experimental Fish fed with the control-fed group (CT) having a fold change of 1.436±0.791. However, TNF-α expression was downregulated in Phytobiotics Fish fed leaf-based diet, with garlic (C) fed group having a higher fold change of 0.288±0.0880, ginger (B), with fold change of 0.196 ± 0.145, moringa (A) with a fold change of 0.124 ± 0.034 and a combination of the supplements (D) with a fold change of 0.097 ± 0.30 (Table 2). These results revealed that the Fish fed Phytobiotics leaf-based diet compromised the action of the innate immune gene TNF-α, despite being shown to have phytochemical properties improving fish health while the upregulation observed in Fish fed with the control diet presumes there is a significant expression of TNF-α, which is advantageous in pathogen resistance. This finding is contrary to Aklilu *et al.* (2020) who stated that medicinal plants have different activities such as growth promotion, increased immunity, disease resistance, antistress, appetite stimulation, aphrodisiac and antimicrobial properties due to the presence of bioactive components such as alkaloids, flavonoids pigments, phenolics, terpenoids, steroids and essential oils.

Subsequently, TNF-α plays a crucial role in the rapid inflammatory response against environmental pathogens, this indicates that the garlic and ginger supplements possess anti-inflammatory properties.

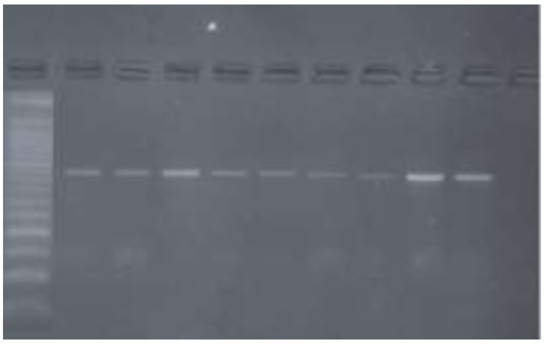

Figure 1: Gel Image capture of TNF-α PCR amplicons ran on 2% Agarose gel electrophoresis, with expected bands size 150bp. Samples were loaded in Triplicate from left to right CT, A, B, C, D

Table 2: The gene expression level of different experimental Fish fed with different Phytobiotics supplements

Sample	Fold change
CT	1.436±0.791
A	0.124±0.034
B	0.196±0.145
C	0.288±0.088
D	0.097±0.30

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ASSESSMENT OF HOMESTEAD AND COMMERCIAL FISH FARMS USING PLASTIC TANKS FOR REARING FISH IN JOS METROPOLIS

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ABSTRACT
The study compared production of fish in plastic tanks at both homestead and commercial farm levels in Jos metropolis, Plateau State. Purposive and Snow balling sampling techniques were employed to identify 44 Fish farmers as respondents. Field visits were conducted; oral interview and farm records were employed for data collection. Physicochemical parameters of water were measured in three commercial fish farms A, B and C. Data collected was analysed using percentages and means. Majority (66%) of the fish farmers did not receive training on fish farming while few (34%) did. More males (66%) than females (34%) were into the business. The age range of the respondents was mostly 35-45 (52%) then 25-35(27%) and 45-55(21%). The highest educational qualification of the respondents was mostly at the level of secondary (45%), followed by primary (39%), then tertiary (16%). Most (77%) were small scale/subsistent farmers while few (23%) were commercial. 73% of the fish farms had experience of 1 – 3 years on the business. Farms A and B had low stocking densities (fish/litre) of 1:3 and 1:1 respectively while farm C was overstocked with 4:1; 84% of the respondents reported high rate of incidence of fish mortality with the leading cause being poor water quality (31%) then diseases (21%) followed by fish stocking density (15%). Fish mortality occurred at all stages of growth but highest at fry (40%) then at fingerlings (34%) followed by juvenile (17%) and adult (9%). Majority (59%) of the farmers culture their fish for a period of 4 – 7 months before harvesting. The mean values of the physicochemical parameters of water in plastic tanks of the commercial farms for pH (7.0±1.96), temperature (28.0±3.55ºC) and dissolved oxygen (5.0±1.4ppm) were within the normal range for the growth and survival for fish. The farmers were observing good sanitary habits on the farms. Since mortality was highest at fry stage of fish growth and development; therefore, measures to mitigate this should be further investigated and success of which should be disseminated to the farmers.
Keywords: *Plastic Tank, Homestead, Fish Farming, Stocking Density, Fish Mortality, Physicochemical Parameters*

INTRODUCTION
According to World Review of Fisheries and Aquaculture (WRFA) (Anon, 2012), world fish food supply has grown tremendously from period 1961–2009 with an average growth rate of 3.2% per year therefore, outpacing the increase of 1.7% per year in the world's human population. This is an indication of the great potential in fisheries if properly harnessed, to solve world hunger. FAO (2014) reported that international trade recorded in 2012, 37% of the total fish production in value, with a total export value of 129 billion United State dollars, of which 70 billion dollars constituted mostly tropical countries' exports. Estimates indicate that small-scale fisheries contributed about half of global fish catches.

If aquaculture's potentialities are well explored, it can reduce over dependence on importing fishery products; one of the most important animal proteins in terms of food availability in the tropics, poverty alleviation, form of employment, income generation and foreign exchange earnings is fish (FDF, 2005). Fish farming implies some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators and so forth. This can involve individual or corporate ownership of the stock being cultivated. In recent times, aquaculture technology allows the commercial and viable production of a number of aquatic organisms through the management of their entire life cycles by developing all aspects of fish husbandry, such as the facilities required for the various life-cycles stages (brood stock holding tanks/sea cages, nursery tanks/cages and grow-out facilities). Others may include feed production, fish handling systems, and disease control. Such procedures and techniques have been developed for several fish species (Eze *et al*., 2011). Three types of fisheries management strategies have been identified as Traditional, Modern and Mixed (Yildiz *et al*., 2011) while culture methods could be monoculture or polyculture which any could be semi-intensive, intensive or super-intensive system (Abdulkarim and Yusuf, 2015).

Kolo (1996) observed inadequate environmental conditions as one of the major factors that limit fish production. Such factors include water quality relating to physical, chemical and biological properties of the ponds. Physical factors that are important in domestic fish farming include shape and size of fish pond, types of substrata material, temperature, turbidity and pond transparency while the chemical factors include, dissolved oxygen (DO) alkalinity, hardness of water, hydrogen ion concentration (pH), conductivity and mineral constituents such as nitrates and phosphates; these are often referred to as physicochemical parameters. The objectives of this study were to investigate fish farms rearing fish in plastic tanks within Jos metropolis in order to assess the water quality; determine the causes of fish mortality and evaluate the hygienic conditions of the farms.

MATERIALS AND METHODS

Study area

The study was conducted in Jos the capital of Plateau state, Nigeria. Plateau state get its name from the Jos plateau, a mountain area in the North of the state with Captivating rock formation. The altitude range from around 1, 200 meter to a peak of 1,829 meter above sea level in the Shere Hills range near Jos. Plateau state is located between latitude 8^{0}24' N and 10^{0}30'N and longitude 8^{0}32'E and 10^{0}38'E. It has an area of 26,899km^2. Average monthly temperature range from 21 – 25^{0}C and from mid-November to late January, night temperature is 7^{0}C. The state also has a total population of 1,586,679 at a growing rate of 2.7% per annum (National population commission, 2006). Plateau state shares boundary with Bauchi State to the North-east, Kaduna State to the North-west, Nasarawa state to the South-west and Taraba state to the South-east (Wikipedia, 2023).

Data Collection

Data were collected on several parameters such as age of the fish, management and physiochemical parameters of water in plastic tanks. The data were also obtained from oral interview and fish farm records. Field visits to the farms were done twice a week throughout the period of the study. The commercial fish farms used in Jos Metropolis remain anonymous as Farms A, B, and C. Purposive and snow balling sampling techniques were used to identify 44 Fish farmers as repondents.

Data analysis

All data generated during the research were analysed using percentage and mean

RESULTS AND DISCUSSIONS

Results achieved through this study are presented in Tables below:

Table 1: Distribution of respondents by their demographic features in Jos Metropolis

Demographic features	Categories	Percentage (%)
Sex	Male	66
	Female	34
Age (Years)	25-35	27
	35-45	52
	45-55	21
Highest Educational qualification	Primary	39
	Secondary	45
	Tertiary	16

Table 1 elucidates the demographic features of the respondents. The results revealed that there are more males (66%) than females (34%) in the business. The age range of the respondents was mostly 35-45 (52%), 25-35(27%) and 45-55(21%). The highest educational qualification of the respondents was mostly at the level of secondary (45%), followed by primary (39%), then tertiary (16%) which indicates that no qualification is required in the business; however, from another perspectives if fisheries is emphasised on as a trade subject in secondary schools, it can promote self-employment, economic productivity and self-reliance at a very tender age of youths. This study was similar to those obtained by Dirican *et al.* (2008) in his evaluation of aquaculture in the Sivas.

Table2: Profiles of the three commercial fish farms purposively sampled in Jos Metropolis

Fish Farm	Capacity of Tanks (Litre)	Number of Fish Stocked	Number of Sorting Tanks	Daily Feeding Schedule	Number of fish/Litre
A	4500	3000	2	2	1:3
B	7500	15,000	2	2	1:1
C	2500	10,000	1	2	4:1

From Table 2, it could be observed that the highest stocked fish was in farm B (15,000) with though 15,000 litre capacity tanks (7500 x 2) giving a stocking density of one fish per litre (1:1) of water; however, this is luxurious or under stocking while one fish per 3 litres (1:3) of water as obtained in farm A was too luxurious as the ideal stocking density for a table size *Clarias gariepinus* based on recommendation of Abdulkarim and Yusuf (2015) is 2 fish per litre of water. On the other hand the stocking density of farm C (4 fish per litre of water) is overstocking.

Table 3: Some Management Skills of Fish Farmers in Jos Metropolis

Description	Class	Percentage (%)
Professionally Trained on Aquaculture skill	Yes	34
	No	66
Experience (Years)	1 – 3	73
	4 – 7	20
	>7	7
Type of fish farming	Commercial	23
	Homestead	77
Time of Harvest (Months)	2 – 3	29
	4 – 7	59
	>7	12

Table 3 elucidates the present status of fish farming in Jos Metropolis the result revealed that 73% of the fish farms were established between 1 – 3 years ago followed by 20% that were between 4 – 7 while 7% were those that have been in the business for more than 7years . The result also revealed that the level of operating was mostly homestead (77%) which production were mainly for consumption 23% were commercial fish farmers. Majority (59%) of the farmers culture their fish for a period of 4 – 7 months before harvesting which corroborates with the commonly reared period of *Clarias gariepinus* to table size (0.5 – 1kg or >1kg) among fish farmers as reported by Abdulkarim and Yusuf (2015).

Table 4: Respondents' reports on Incidence of Fish Mortality, Causes and Fish Growth Stage of Occurrences

Parameter	Category	Percentage (%)
Incidence of Fish Mortality	High (Frequently occurring)	84
	Low (Less frequently occurring)	16
Causes of Fish Mortality	Aquatic Environment (Predation, injuries, and so forth)	10
	Natural/ Unknown	10
	Poor Water Quality (Pollution)	31
	Feed Contamination	13
	Fish Stocking Density (Overstocking)	15
	Diseases	21
Fish Mortality at Stages of Growth	Fry	40
	Fingerling	34
	Juvenile	17
	Adult	9

Table 4 elucidated that 84% of the respondents reported high rate of incidence of fish mortality with the leading cause being poor water quality (31%). The second leading cause was reported to be diseases (21%) followed by Fish stocking density (15%). The report further elucidated that the respondents experienced significant fish mortality at fry stage of growth (40%) then at fingerlings stage (34%) while fish mortality occurred less at juvenile (17%) and adult (9%) stages. The sanitary habits of the farmers were observed to be generally commendable in terms proper disposal of used water from the plastic tanks.

Table 5: Mean Water Quality (Physicochemical) Parameters

Parameter	Farm A	Farm B	Farm C	Mean ±Standard Deviation
Temperature	26.2	27.8	26.5	28.0±3.5
pH	7.7	7.1	7.2	7.02± 1.9
Dissolve Oxygen (D.O.)	4	5	5	4.0±1.4

Table 5 revealed the mean water quality parameters of fish reared in plastic tanks from the three purposively sampled commercial farms in Jos metropolis. The study showed that the water parameters such as the pH (7.0±1.96), temperature (28.0±3.5) and dissolved oxygen (5.0±1.4) are good for fish production as they are within the tolerable ranges for the survival and growth of the fish (Abdulkarim and Yusuf, 2015).

CONCLUSIONS AND RECOMMENDATIONS

The mean values of the physicochemical parameters of water in plastic tanks of the commercial farms were within the normal range for the growth and survival of fish. As water pollution was reported to be the first leading cause of mortality in plastic tanks reared fish among homestead fish farmers; hence, monitoring of water quality parameters is hereby recommended as a critical practice in fish farming. Mortality was found to be most occurring at fry stage of fish growth and development therefore; measures to mitigate this should be further investigated and disseminated to the farmers. Furthermore, Agricultural Development Project or any Non-governmental Organization should embark on extension services delivery and training to the fish farmers in order to build adequate skills required for sustainable fish farming among homestead and commercial fish farmers. The hygienic practices should be sustained as observed amongst farmers.

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HEAVY METALS' CONCENTRATIONS IN SOME ORGANS OF FISH SPECIES, SEDIMENTS AND WATER OF DADIN KOWA DAM, NIGERIA

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ABSTRACT
Bioaccumulation effects of heavy metals through food chains are of great public health concern as the heavy metals are toxic, at certain mean concentrations (MC), to humans that are at the top of food chains and webs. The aim of this study was to determine heavy metals' concentrations in samples of water, fish (Clarias gariepinus and Oreochromis niloticus) and sediments of Dadin Kowa dam. Temperature and pH of the water were measured with digital pen type thermometer and pH meter respectively. Atomic Absorption Spectrophotometer was used to measure the concentrations of the heavy metals: Copper (Cu), Nikel (Ni), Cadmium (Cd), Zinc (Zn), Chromium (Cr) and Lead (Pb). The water has ranges of mean values of temperature (30.90˚C– 32.0˚C) and pH (6.53 – 6.84). MC (mg/L) of Zn was highest (1.447and 0.944) in the gills and muscles for O. niloticus, while lowest (0.391 and 0.179) for C. gariepinus respectively. O niloticus bones and muscles had the same (0.012) MC of Cr which were higher (0.006 and 0.010) than in same organs of C. gariepinus. MC of Cu was observed to be relatively higher (1.165 – 0.11) in sediments while lowest (0.59 and 0.48) in water. MC of Cd in the sediments ranged from 0.11-0.01 and was 0.112 – 0.105 in water. The Temperature and pH of Dadin Kowa dam were suitable for fish survival; however, MCs of Pb, Zn, Ni and Cd in the fish species, sediments and water samples were observed to be higher than the World Health Organisation (WHO) permissible limit. Therefore, we call on relevant governmental and non-governmental agencies to further investigate our findings for proper action to be taken in order to save guard the public health.
Keywords: *Pollution, Health Risk, Heavy Metal Concentration, Dadin Kowa Dam*

INTRODUCTION
Improper discharge and uncontrolled applications of industrial wastes and pesticides on land and in water bodies containing pollutants such as zinc, cyanide, copper, lead, mercury and cadmium cause death and an increment in toxic level of fish species and aquatic ecosystem health. These and many other contaminants and waste product contribute high levels of synthetic organic compounds and heavy metals which subsequently find their wayfr3 into the Dadin kowa Dam. However, the incorporation of these heavy metals by aquatic organisms into their body systems during feeding may remain for a very long time and these can pass on in the food chain. Heavy metal refers to any metallic elements that has a relatively high density (4mg/cm^3) and is toxic or poisonous even at low concentration. The concentration of essential heavy metal under acceptable limit is good for health. However, if it exceeds the acceptable limit, these heavy metals may become harmful and extremely toxic to human and it result to deficiency diseases or syndromes if not in adequate amounts. The American Heart Association recommended consumption of fish at least twice per week in order to reach the daily intake of omega-3 fatty acids (Kris-Etherton *et al.,* 2002). However, fish normally accumulate heavy metals from food, water, and sediments (Yilmaz *et al.,* (2007), Zhao *et al.,* (2012) this reported that it is a good indicator of heavy metals contamination in water (Voegborlo *et al.,* 2012). Rivers support large proportion of fish species of varying composition; these fish species provide affordable sources of food and quality protein to the surrounding communities. The study aimed at assessing the concentrations of some heavy metals in commercially important fish species from Dadin kowa Dam, Gombe State so as to establish a baseline data on the current pollution status of the Dam.

MATERIALS AND METHODS

Study Area

Dadin kowa dam is 37 km from Gombe town and about 5 km North of Dadin kowa village in Yamatu- Deba Local Government Area (L.G.A) of Gombe state. It shares common boundary with Akko L.G.A in both the south and west, Yamaltu-Deba to the East and Kwami to the north. The Dam is situated between latitude 10 19' 19''N and longitude 11 28' 54''E of the equator (Nigeria Galleria, 2021).

Sample Collections

Samples (water, fish, and sediment) were collected to determine the concentration of heavy metals from Dadinkowa dam, Gombe State, Nigeria. Samples from different sources were collected around the head, middle and tail of water of the dam. Plastic containers, washed with de-ionized water, were used in collecting water samples. Samples of fresh fish species: two *Clarias gariepinus* and two *Oreochromis niloticus* were obtained randomly from fishers fishing in the dam. The Fish species were kept in polythene bag and stored in the ice box for transportation to laboratory for analysis. Sediment samples were collected (1-2 cm) from the bottom of linnet zone with a spade and stored in a sealed polythene bag.

Digestion of samples

Digestion of water, fish species and sediments were carried out according to the method described by Öztürk *et al.*, (2009) in triplicates while the heavy metal analysis was done using Atomic Absorption Spectrophotometer (AAS) model: 210 VGP from the Department of Engineering, Abubakar Tafawa Balewa University Bauchi (ATBU) Bauchi. The instrument (AAS) operating conditions were set in line with the manufacturer's specifications.

Data analysis

The data were analyzed using Statistical Package and Service Solution SPSS version 25.0 for Windows (SPSS, IBM. 2017) whereby the means, standard deviation and standard error were obtained.

RESULTS AND DISCUSSION

Table 1 revealed the mean temperature and pH of Dadin Kowa dam water. Tail water of the dam had the highest (32.0^0C and 6.84) mean temperature and pH while the middle water had the lowest (30.9 and 6.53) mean temperature and pH respectively. Dadin kowa dam water was slightly acidic.

Table 1: Mean Temperature and pH of Dadin Kowa Dam Water (Jan, 2023)

Month	location	Temperature (^{0}C)	pH
January, 2023	Head	31.3	6.61
	Tower (Middle)	30.9	6.53
	Tail water	32.0	6.84

Table 2 elucidates that, the mean concentrations of Zn were highest (1.447 and 0.944) in the organs (bones and gills) of *Oreochromis niloticus* while lowest (0.391 and 0.179) in the organs (bones and gills) of *Clarias gariepinus* respectively.

Oreochromis niloticus bones and muscles had the same (0.012) mean concentration of Cr, and were higher than in the bones (0.006) and muscles (0.010) of *C. gariepinus* (Table 2).

Table 3 revealed that, the mean concentration of Cu was the highest (1.165) in the head of sediment while lowest (0.590) at the tail of the dam water. Mean concentrations of Cd in the sediments (tail and head) ranged from (0.11 -0.91) and the mean concentration of Cd in the dam water range from (0.112 – 0.105) in the tail and head respectively.

Table 2: Mean Heavy Metals' Concentrations (mg/L) in Organs from Fish in Dadin Kowa Dam (Jan, 2023)

Samples	Fish organs	Cu	Ni	Cd	Zn	Cr	Pb
Clarias gariepinus	Gills	0.705±0.02	0.088±0.01	0.078±0.00	0.179±0.11	0.001±0.00	0.028±0.01
	Bones	0.636±0.24	0.096±0.00	0.078±0.00	0.391±0.35	0.006±0.00	0.031±0.01
	muscles	0.922±0.27	0.015±0.01	0.088±0.00	1.296±0.63	0.010±0.00	0.021±0.00
Oreochromis niloticus	Gills	0.698±0.09	0.096±0.01	0.092±0.00	0.944±0.47	0.008±0.00	0.026±0.01
	Bones	1.049±0.31	0.117±0.01	0.092±0.00	1.447±0.13	0.012±0.00	0.023±0.00
	Muscles	0.623±0.19	0.321±0.01	0.094±0.00	0.148±0.12	0.012±0.00	0.024±0.01

Table 3: Mean heavy metals' concentrations (mg/L) in water and sediments of Dadin Kowa Dam (Jan, 2023)

Samples	Locations	Cu	Ni	Cd	Zn	Cr	Pb
Sediments	Head	1.165±0.11	0.159±0.02	0.091±0.01	0.711±0.71	0.013±0.00	0.018±0.00
	Tail water	0.908±0.23	0.184±0.02	0.011±0.00	0.705±0.13	0.011±0.00	0.008±0.00
Water	Head	0.750±0.03	0.204±0.02	0.105±0.06	0.573±0.04	0.023±0.00	0.033±0.01
	Tail water	0.590±0.03	0.226±0.01	0.112±0.00	0.476±0.04	0.019±0.00	0.026±0.00

Physical and chemical parameters of Dadin Kowa Dam water

The mean temperature recorded in Dadin Kowa dam water were within the recommended temperature range for 'warm water fishes' which was 25-32^{0}C and 14-18 °C for 'cold water fishes' (Trivedi, 2020). According to the author temperature of Dadin kowa dam water may be suitable for fish survival, growth, and reproduction. Temperature of water had a potential implication on the oxygen retention capacity (CWT, 2004). A pH range of Dadin Kowa dam water ranged from 6.53 to 6.84 (Table 1). This indicated that, Dadin kowa dam water was slightly acidic. These values were suitable for domestic and drinking water purposes (WHO, 2017). This lower value of pH may be attributed to runoff of inorganic fertilizer from adjacent farms within the dam. Spellman (2017) stated that, pH is one of the most important parameters of water quality.

Heavy metals mean concentrations in some organs of fish species (*Clarias gariepinus* and *Oreochromis niloticus*) from Dadin Kowa Dam

The following heavy metals were identified in both *C. gariepinus* and *O. niloticus*: Copper (Cu), Nickel (Ni), Cadmium (Cd), Zinc (Zn), Chromium (Cr), and Lead (Pb) (Table 2). Mean concentrations of Zn was found to be highest in the bones and gills of *O. niloticus* and lowest in *Clarias gariepinus*. The mean value of the heavy metals obtained in the fish species were above the permissible limits (WHO, 2017) respectively.

Zinc (Zn) is an essential trace element whose threshold value in surface and groundwater normally do not exceed 0.01 and 0.05 μg/l, respectively (Vinodhini and Narayanan, 2009). Deficiency of zinc causes several physiological disorders such as poor pregnancy rate, cardiovascular diseases and cancer; but it becomes toxic in excess amount (Azaman *et al.,* 2015). However, concentrations in tap water can be much higher as a result of dissolution of zinc from pipes. WHO (2003) stated that, drinking water containing zinc levels above 3 μg/l may not be acceptable for consumption.

The mean values of Cu and Cr obtained in the fish species were below the permissible limits (2.0 and 0.05) recommended for fish consumption (WHO, 2017). High concentration of Cu in dam water may be due to mining activities close to the dam water, similar findings indicate that, the major source of copper (Cu) in water was due to mining activities within the dam (Adelekan, 2011). Higher concentrations Cu in organism can lead to neurological complications, hypertension, abdominal pain, diarrhea, kidney and liver dysfunctions (Tirkey *et al.,* 2012).

O. niloticus bones and muscles had the same mean concentration of Cr; while *C. gariepinus* bones and muscles had different concentrations Cr obtained in the fish species were below the permissible limits (0.05) recommended (WHO, 2017). Furthermore, O'Brien *et al.,* 2001, Matsumoto, 2006) and WHO, (2015) implied Chromium have been associated with slow healing ulcers in organisms. It has also been reported that Chromate compounds can destroy DNA in cells. Recommended safe limits for Cr (hexavalent) in wastewater and soils used for agriculture are 0.05 and 0.1 ppm respectively (Chiroma *et al.,* 2014, Aneyo *et al.,* 2016). Lead (Pb), Zinc (Zn), Nikel (Ni), Cadmium (Cd) was above permissible limits in all the fish species. These heavy metals were the major causes of water contamination and poison in Zamfara state (Mahuta, 2020). The WHO, (2011) recommended 0.01 and 0.1 ppm as the safe limits of Pb in wastewater and soils used for agriculture. The high mean concentration of Nickel (Ni) in dam may be due to wastewater runoff from farms in to the dam. WHO recommended safe concentration of Ni to be 0.02 and 0.05 (Chiroma *et al.,* 2014, and Aneyo *et al.,* 2016). The recommended safe limits of Cd were 0.003 ppm in both waste water and soils for agriculture by World Health Organisation (Chiroma *et al.,* 2014, and Aneyo *et al.,* 2016).

The mean concentration pattern of heavy metals in fish species of all the organs obtained in Dadin kowa dam (muscles, bones and gills) for *C. gariepinus* and *O. niloticus* were Zn>Cu>Ni>Cd<Pb>Cr. Ekpo *et al.*, (2013) mentioned the target organs of heavy metals in fish was the metabolically active ones which accumulate high level of metals gills, bones and muscles of fish species.

Mean concentrations of heavy metals in sediments and water (head and tail of the water) in Dadin Kowa Dam

Mean concentration of Cu and Zn in the dam sediments were higher while in the tail water lowest (Table 3). Lead (Pb), Zinc (Zn), Nikel (Ni), Cadmium (Cd) was above permissible limits in sediments and water, while Cupper (Cu) and Chromium (Cr) were below permissible limits in domestic and drinking water (WHO, 2017). Some of these heavy metals such as cobalt, chromium, copper, magnesium, iron, molybdenum, manganese, selenium, nickel and zinc are essential nutrients that are required for various physiological and biochemical functions in the body. When heavy metals were not in adequate amount in the feed, it may result to nutritional diseases. Furthermore, when they are in large concentrations in the feed, they may cause acute or chronic toxicities (WHO, 1996).

Contamination of sediments with heavy metals is an environmentally affecting aquatic organisms and human health. However, heavy metals accumulation in the sediment and bottom of dam, did not have any possibility of flowing out, outflow from the dam, outflows of heavy metals usually occur at the surface level. Sediments act as the main pool of metals in the aquatic environment. Presence of heavy metals in sediments indicates the status of water pollution (Zahra *et al.*, 2014).

CONCLUSION

The study elucidates that, Dadin kowa dam water is slightly acidic due to pollution. The following heavy metals were detected in the dam water Zn>Cu>Ni>Cd>Pb>Cr. Zinc is the most abundant heavy metal in the bones of *O. niloticus* and muscles of *C. gariepinus*. Mean Concentrations of Pb, Zn, Ni and Cd in the fish species, sediments and water samples were observed to be higher than the World Health Organisation (WHO) permissible limit.The findings of this research are indicating the likelihood that Dadin kowa dam is polluted with heavy metals.

RECOMMENDATIONS

The government should have a framework strategy to broadly survey the Dadin Kowa dam, whereby specific sources of pollution should be identified in order to curtail it; People should be advised to be cautious in utilizing water and *O. niloticus* and *C. gariepinus* caught from Dadin kowa dam. The public should be educated on the harmful effects of toxicity of heavy metals particularly, the bioaccumulation effects. Furthermore, research should be carried out by relevant governmental and non-governmental agencies to further investigate our findings for proper action to be taken in order to save guard the public health.

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CORRELATION ANALYSIS OF FISH CONSUMPTION PATTERN AMONG HOUSEHOLDS IN LAGOS STATE, NIGERIA

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ABSTRACT

This study analyzed the correlation of fish consumption among households in Lagos State. A multistage random sampling technique was used to select 400 household fish consumers. The first stage was the stratification of the study area into cells of high, medium and low-density area of Lagos state. In the second stage Two Local Government Area was selected from each of the cells (Lagos Island, Eti Osa, Surulere, Shomolu, Kosofe and Oshodi/Isolo Local Government Area. In the third stage a list of all the households in each of the Local Government Area was obtained from the National Population List. A structured questionnaire was used to collect the data needed for the study.The data were analyzed using the descriptive statistics and inferential statistics (multinomial logit model and multiple regression). The result shows the male household are more (52.5%) than the female household (47.5%). The average monthly expenditure on fish by household was ₦5.9. Result of the descriptive statistics further shows that the largest number of consumers (60.7%) had preference for fresh fish.. Smoked fish was the second most preferred fish form consumed by the households (54.7%). While dried fish emerged was consumed by 52.7% of the households making it the third preferred fish form. The least preferred form of fish consumed in the area was frozen fish and 50.7% of the household consumed this fish form. The result of the multinomial result shows that Education, Age, mode of income, Gender and Household income were statistically significant at 5% Level of probability. The multiple regression result shows that only three regresors (Age, Household income, and marital status) out of seven regressors were statistically significant at 5% level of probability. The study recommends the improvement of the market for fish consumption by creating value through packaging processing and storage and better storage facilities. This can be achieved by government provision of steady power supply and agro processing industries which must be linked to production for household consumption.

Keywords: *Analysis, Correlation, Fish Consumption, Pattern, Lagos-State.*

INTRODUCTION

The fishery subsector in Nigeria holds the potential to contribute to food security and reduce rural fishery sub sector hunger by providing employment to many Nigerians, it is also a major contributor to GDP. Its contribution to GDP as at 1990 Constant basic prices stood at ₦9,240.54, ₦ 9,810.63, ₦10,395.40 and ₦1,012.63 in 2008, 2009, 2010 and 2011, respectively (Central Bank of Nigeria, 2011). Apart from providing employment for over five hundred thousand people, it contributes over 40 percent of the animal protein intake of the resource poor people (Sani *et al.*, 2009).

Fish is an important component of a modern healthy diet and also a critical food source for developing countries Fish provides key macro and micro nutrients, protein and are low in saturated fat (Lynch & Macmillan, 2017). fish consumption has been linked to a wide array of health benefits for infants and adult including the developing foetus (Millen *et al.*, 2015) According to Nesheim and Taktine (2007), fish can supply up to 50 percent or more of high quality protein, mineral elements (B6, B12, niacin, thiamine, riboflavin, Vitamin E) and essential fatty acid such as oleic acid and omega3 fatty acid.

The United Nation Food and Agriculture organization noted that world population growth has outweighed fish production due to increased fish consumption. (FAO. 2018c) Fish consumption per capita across the world has increased from 9.0kg in 1961 to 20.5kg in 2017 FAO (2018d). Considering the upsurge in population growth, urbanization and demographic dynamics (Falaye & Jenyo-Oni, 2009). Fish consumption (demand) raises enormous challenges for Nigerian economy. Utilization of fish varies for food and non-food purposes across countries and regions. More importantly, the utilization of fish for direct human consumption increased significantly over the years from 67 percent to 88 percent in 2016 (Verbeke,& Vakier, 2015). Hence, the consumption pattern for fish has peculiar implications for the sub-sector in various economies.

Fish plays a vital role in feeding the world's population and contributing significantly to the dietary protein intake of hundreds of millions of the populace. On a global scale, almost 16 percent of total average intake of animal protein was attributable to fish in 1988 (FAO 1990). In the developing worlds, fish is a highly acceptable food that supplies as much as 40 percent of all animal protein available of the countries. The low income earners in Nigeria consume proportionally more of fish than meat or other sources of animal protein. Over the past 15 years, however, fish has enjoyed an explosive increase in demand and this demand has also increase its price. There is heightened awareness in the developed world of the nutritional and health benefit of fish products low in fat and calories and high in protein, vitamins, mineral and polyunsaturated fatty acids. Increased attention to fish and fish products caused prices to spiral with potentially serious consequences for consumers. While the bulk of fish harvested is still used for domestic consumption. Increased world demand for fish is placing pressure on developing countries to export fish to earn foreign exchange. The objectives of the study are to:examine the socio-economic characteristics of the household, determine the factors influencing consumer's expenditure on fish and identify the constraints for fish consumption in the study area.

METHODOLOGY

This study was carried out in Lagos State Nigeria. Lagos State is located in the south-western part of the Nigeria. On the North and East Lagos is bounded by Ogun State. In the West the state shares boundaries with the Republic of Benin. Lagos state is bounded to the south by Atlantic Ocean. Twenty two percent of state land area (3,577 km^2) are lagoons and creeks. Lagos state lies within the latitude 6^0 and 24^1 and 6^0 31^1 N, longitude $3^0 16^1$ and $3^0 37^1$. There are twenty local Government Areas in Lagos State. The state has a population of 9,013,534. (National population commission, 2006). The highest maximum temperature ever recorded in Lagos was 37.3ºC (99.1ºF) and the minimum 13.9ºC (57.0ºF) (Lagos Meteorological Organization 2012). . A multistage random sampling technique was used to select 400 household fish consumers. The first stage was the stratification of the study area into cells of high, medium and low-density area of Lagos state. In the second stage Two Local Government Area was selected from each of the cells (Lagos Island, Eti Osa, Surulere, Shomolu, Kosofe and Oshodi/Isolo Local Government Area. In the third stage a list of all the households in each of the Local Government Area was obtained from the National Population List. A structured questionnaire was used to collect the data needed for the study.The data were analyzed using the descriptive statistics and inferential statistics (multinomial logit model and multiple regression)

RESULT AND DISCUSSION

Table 1. Socio-economcs Characteristics of Respondents in the study Area.

Variable	Category	Frequency N= 400	Percentage	Mean	Standard Deviation
	Male	210	52.5		
	Female	190	47.5		
	Single	155	38.75		
	Married	215	53.75		
	Widowed	30	7.5		
	Less than 20 years	68	17.0	3,640.00	11.57294
	21 – 30 years	80	20.0		
	31 – 40 years	88	22.0		

41 – 50years	103	25.75		
50years and Above	61	15.25		
Informal education	68	17.0		
Primary school	88	22.0		
Adult literacy	61	15.25		
Secondary school	103	25.75		
Tertiary school	80	20.0		
Nuclear Family	198	49.5		
Extended Family	202	50.5		
< 2	145	36.25	4,5467	10.6
2----5	213	53.25		
>5	42	10.5		
< ₦10,000	39	9.75	13,954500	5.9
10,00--₦19000	45	11.25		
20,000--₦29,000	66	16.5		
30,000-₦39,000	69	17.25		
40,000-₦49,000	78	19.5		
50,000 and above.	103	25.75		
Salary	182	45.5		
Non-Salary	218	54.5		
Farming	50	12.5		
Civil Servant	102	30.7		
Trading	130	32.5		
Banking	70	17.5		
Artisan	53	13.25		

Source: Field Survey Data, 2023.

The socio-economic characteristics analyzed include: gender, age, marital status, family size, household income, occupation and forms of fish consumed.

Gender of the household heads is an important factor that has significant influence on the preference and consumption pattern of fish by households. The distribution of household by gender and forms of fish is presented in Table 1.0 and shows that although the percentage of male headed households (52.5%) was more than female headed household (47.5%), the difference was marginal. This is in line with result of Chianu & Tsujii(2007) where 99.7% of the surveyed household were male headed. The distribution of the household by marital status is presented in Table 1.0. The table shows that 53.75% of the households were married while 38.75% are and 7.5% were singles and widowed respectively. This shows that there is the tendency for more purchase of fish. and increased consumption by households headed by married people than singles due to expansion in family size and greater responsibilities in terms of expenditures on food items. Therefore there is a tendency for more purchases of fish. (Amao & Ayantoye 2014). According to Aminu *et al*. (2016) there is a tendency for the age of the household head to affect the consumption pattern of a household and may determine to an extent the type, quality and nutrition of a given household. The table shows that 25.75% of household heads fell within the age group of 41-50years. Age could be an important determinant in the quality and quantity of protein requirement of an individual and households because food consumption pattern generally follows the body consumption (Amao *et al.*, 2006). Amao & Ayantoye, 2014). Educational status and years of education changes taste over time and usually affects consumption pattern, preference for food items and nutrition of a household. This is because consumers become aware of the nutritional value of food items like beef, eggs and fish and subsequently enhance their consumption. The distribution of household head by level of educational attainment is presented in Table 1.0. The result shows that household heads with secondary education had the highest percentage of 25.75%. This was followed by households head with primary education having 22.0%. Household's heads with tertiary education having 20.0% and households head with informal education was 17.0% of the total respondents. Respondent that went through adult literacy education had the least percentage (15.25%).This is in agreement with Babalola D. A & Isitor S .U, 2014) which state that that increasing educational status have positively impact on food expenditure.

Result in Table 1.0 shows that majority of the respondents (50.5%) belong to an extended family in the study while those with nuclear family is less with a sample household of 49.5%. This result shows that household with extended family are more than household with nuclear family. Family size have a significant effect on the consumption pattern of fish consumed. As the family size increases, there is tendency for the household to consume more food generally, fish inclusive. Table 1.0 shows the distribution of household family size. The result shows that high percentage of the household had between 2-5 members representing 53.25% of sample household. This is followed by household with < 2 members representing 36.25% of sample household and >5 representing 10.5% of sample household. This result towards small family size in the study area which may be attributed to the level of education of the respondents and their corresponding awareness of family planning measures. Information on demographic patterns in Nigeria also shows that urban households are usually smaller than rural households (Statista Research Department, 2021) The frequency distribution of income determines the type of income distribution most prominent in the study area. Table 1.0 shows that, about9.75% of all households sampled earn less than ₦10,000 per month. About 11.25% are in the range of ₦10,000--₦19000 per month, while about 16.5%fall within the income group of₦20,000--₦29,000per month. Households earning between ₦30,000-₦39,000permonthconstitute about17.25 percent of all respondents interviewed, while those earning between ₦40,000-₦49,000 and ₦50,000 and above per month, accounted for19.5%, and 25.75% respectively of all the households sampled in the study area. This reveals that majority of the households in the study fall within the low income group as presented in Table 1.0 while those in the high income class are relatively few. Low income may affect overall fish consumption and further determine the form of fish consumed by households
Table 1.0 shows that 54.5% of total sampled respondents were non salary earners. 45.5% of total sampled respondents were salary earners. A priori expectation is that the probability for salary earners to have a more planned and consistent consumption pattern than the non- salary earners is higher. This may also influence an increase in household purchasing power. However, most of the household in the study area are non-salary earners. Table 1.0 shows that 32.5% of the total sample had their own business (trading) and represent. 17.5% of household heads were in the professional group comprising of banker. 12.5% of the sample household heads were farmers. 13.25% of sampled respondents were artisans and apprentices accounted for about 13.25% of sampled respondents.
Also Table 1.0 shows the average monthly expenditure on fish by household size, it was observed that the average monthly expenditure (₦13,954,500) on fish increases as the household size increases. This was found to be true for the average monthly expenditure on fish by the age of the household head (₦3,640.00).

Table 2 Multiple regression output showing factors influencing household fish Consumption in the study Area.

Variables	Beta Coeff	t-value
(Constant)	5522.640	6.766
Education level of household head (year)	4.8870	1.176
Age of household head (year)	6.125*	3.713
Household Income (naira)	2.1086*	2.723

Household Size	9.957*	3.140
Mode of Income (Dummy: salaried =0; Non salaried =1)	-6.886	-1.846
Gender (Dummy: male =0;. female =1)	4.993	.014
Marital status (Dummy: Married =1; Single =0)	-1.213	-3.228

Adjusted R^2 = 0.49; F-statistics = 5.493*; Reference category = Fresh Fish form; *P<0.05

Source: Field Survey Data, 2023.

The result of the factors influencing households' fish expenditure in the study area is presented in Table 2. The coefficient of determination, R^2 is 0.49 showing that the linear regression explains 49% of the variance in the data. Since F statistics is significant at (P <0.05), this means there is overall significance of the model.

The beta coefficient of the age of the household head is positive and significant (β=6.125, p=005) thus a unit change in the age (increase) of the respondent will lead to 6.125 change (increase) in fish expenditure. It also shows that the higher the age of the household head, the higher the consumption expenditure on fish. The descriptive result of the age composition of the respondents shows that most of the respondents are relatively old thus it is expected that expenditure on fish will be high if supply is improved in the study area *ceteris paribus*. This findings agrees with Ayanwu (2012) in Rivers state, Nigeria which states that increase in age leads to increase in the quantity of fish consumed.

The beta coefficient of household income is positive and statistically significant as 5 per cent level (β=2.1086, p=0.005) showing that income is directly related to expenditure on fish. This suggests that a change (increase) in household income will cause expenditure on fish to increase by 2.1086. That is, the higher the income, the higher the fish consumption expenditure. This agrees with a priori expectation that with higher disposable income, expenditure on food increases. However, most of the households in the study area are low-income households. This findings is consistent with that of Aromolaran A. B & Akintunde O.A 1998 in Delta State, Nigeria, Fabiyi Y.L 1985 in Calabar, Cross Rivers State, Nigeria and Ayanwu, S.O 2012 in Rivers State, Nigeria.

The beta coefficient of household size is positive and statistically significant at 5 percent level (β=9.957, p=005) of probability, thus suggesting that household size is also directly related to expenditure on fish. It also implies that an increment in the size of the household will lead to an increase in the fish consumption expenditure. Similar result was also obtained by Ibrahim M I999 in Kano and Sharu, A.A 2000 in Sokoto metropolis, Nigeria, in the demand for soybean and meat respectively as sources of protein

Based on the multiple regression result, the earlier stated null hypothesis which says that household personal characteristics do not significantly influence consumer expenditure on fish, is rejected in favour of the alternative hypothesis.

Table 3. Distribution of Respondents according to Constraints faced by Households in the study Area.

Constraint	**Frequency**	Percentage
Distance from the Market	101	67.3
Low Traded Volume of Fish	18	12.0
Health Reasons	41	27.3

Source: Field Survey Data, (2023).

The result in Table 3 reveals that majority (69.3%) of the respondents faced rapid fish spoilage as constraint because they consume fresh fish and preserved by refrigerating or sun drying. Rapid spoilage of fish could be as a result of poor power supply to power the refrigerator use for preservation of the product. While 67.3% sampled fish consuming household accounting for distance from the market as their challenge, other constraint include high price of fish (64%). High prices of the product could be as a result of high transportation, high cost of production and high cost of preservation. Low level of consumer income (41.3%), health reasons (27.3), religious belief (25.3%) and low traded volume (12%).

CONCLUSION

Based on the findings Fresh fish is the highest form of fish in the consumer market, whereas smoked fish is the lowest priced. As the income of the consumers increases, they buy only a little more smoked and frozen fish because most smoked fish consumed in the metropolis are perceived to be of low quality. Wealthier consumers tend to buy more of fresh fish and dried fish (such as stock fish) which consumer perceived to be of better quality in terms of nutrition and safety. The dried and fresh forms of fish are substitute mainly because the most common type of fresh fish in the area (the cat fish) is also the dried fish in the market.

RECOMMENDATIONS

1. With increasing awareness of health and nutritional importance of fish, especially among older folks, supply of fish should be encouraged and facilitated locally through improvement of local production so that low income household can affordably consume
2. Facilitation of supply of fresh and frozen fish is recommended because it attracts higher preference especially in the open market.
3. Based on the findings, the study recommends that fish prices should be stabilized, adequate cold storage facilities should be purchased by the fish mongers
4. Fishery sector should expand their ponds and be encouraged to produce more fresh fish at affordable prices for the masses.
5. It has been revealed that a light increment of income distribution in favour of the low income class will improve fish consumption for many of these consumers.
6. There is a need therefore to increase domestic fish supply in the country and ensure fish supplies to consumers at affordable prices in all market in the metropolis.

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EFFECT OF DIFFERENT LEVELS OF DIETARY BETAINE HYDROCHLORIDE ON THE GROWTH RESPONSE OF FRY OF *CLARIAS GARIEPINUS* (BURCHELL, 1822)

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ABSTRACT
Seed production is an inevitable requirement for sustainability of aquaculture industry. This process is basically managing fish at different early growth and developmental stages of its life cycle. However, it has been observed that fry stage is the most critical stage threatened with high rate of mortality. And high growth rate of the fry could catalyse the fish to pass through this critical stage speedily which is an indirect technique to curb mortality as well. In order to achieve this, a study on feeding trial was carried out at the Aquatic Bio-Resources unit of the National Biotechnology Development Agency, Katsina whereby the effects of different levels of dietary betaine hydrochloride on the growth response of fry of Clarias gariepinus were evaluated. ***Betaine*** *hydrochloride* ***was incorporated at*** *0.0g/100g, 0.25g/100g, 0.5g/100g, 0.75g/100g and 1.0g/100g* ***in*** *Coppens fish feeds (0.2 – 0.5mm) of 49% crude protein.* ***The experimental diets were fed to*** *the* ***fry*** *(n = 1,500 with Mean initial weight = 0.26±0.0g)* ***for 28 days in*** *15 plastic hatchery tanks (semi flow-through system)****.*** *Fry were fed at a fixed feeding rate of 5% body weight 4 times daily between the hours of 07:00 and 23:00 at regular interval****.*** *Data generated were analysed using One - way ANOVA at P = 0.05.* ***The results indicated that fry*** *fed* ***diet supplemented with betaine hydrochloride at 0.5g/100g level has significantly the highest values of Mean Weight Gain*** *(2.34±1.02g/fish)****, Daily Weight Gain*** *(0.083±0.09 g/day)****, Specific Growth Rate (****3.57±0.11 %/day)* ***but also significantly least (best) value of FCR*** *(0.155±0.04).* ***Survival rate of over 88% were recorded from each of the fry fed all the diets with betaine hydrochloride and the control (****0.0g/100g****) indicating that the water quality parameters were not affected by the diets used in this study. Therefore, the supplementation of fry feed with betaine hydrochloride can promotes fry growth in hatchery production and is recommended at0.5g/100g level.***
Keywords*:* ***Growth response; Fry of Clarias gariepinus; Betaine hydrochloride.***

INTRODUCTION
Clarias gariepinus (Burchell, 1822) which belongs to the family Clariidae is the most cultured and economically important freshwater fish species that contributes immensely to the annual freshwater fish production in Nigeria (Awodiran *et al.,* 2019). It is readily acceptable among Nigerian fish farmers and consumers; hence, it commands high commercial values, and is an important source of animal protein (Omitoyin, 2007). It also serves as a model organism in research; it is also cultured intensively and extensively in Africa, Europe and Asia (Ali, 2022). The economic benefits of this fish species are due to its hardiness, fast growth, large size attainable and ability to withstand and tolerate harsh environmental conditions (Awodiran *et al.*, 2019).

Aquaculture has been grown rapidly for food production in the last few decades (Ali, 2022). The increase in aquaculture is said to be paralleled with a corresponding increase in the cost of fish feed, since feed is a significant expense in all aquaculture operations, the need to maximize feed consumption and reduce feed wastage is of paramount importance (Murthy *et al.* 2016), that encouraged researchers to develop fish production in different scientific ways to raise quality and quantity production and lower costs, which including special fish diets supplemented with growth promoters as feed additives such as betaine hydrochloride as reported by Leong - Seng *et al.* (2019) which positively affect the body weight gain improvement and decrease food consumption to improve and raise the production level without any negative effect on public health and consumer.

Betaine is amino acid derivatives which is derive from amino acid glycin (is the trimethyl glycin), is a metabolite of plant and animal tissues, betaine is considered as a by - product of sugar beet processing, betaine has nutritional function commonly used as feed additive in animal, poultry and aquatic nutrition, betaine improve growth performance, health status, feed digestibility, palatability, flesh quality and immune status of fish species (Abed Ali and Al - Faragi, 2017). Therefore, this study was carried out to evaluate the effects of different levels of dietary betaine hydrochloride on the growth response of *Clarias gariepinus* fry

MATERIALS AND METHODS

Study Area

The study was carried out at the hatchery room of the Aquatic Bio-Resources unit of the National Biotechnology Development Agency (Bio-resources Development Centre) Katsina, Katsina State. The fry for experiment were bred at the hatchery room of Aquatic Bio-Resources unit of the Bio-Resources Development Centre, Katsina. The fry were 4 days old at the commencement of the feeding trial

Experimental Diets

Coppens fish feeds (0.2 – 0.5mm) were used as the basal diets for this study and were obtained from feed suppliers at Katsina. While the betaine hydrochloride was obtained from Bon Amour Pharmacy Limited Lagos, Nigeria, imported from Piping Rock Health Products, Ronkonkoma, New - York, USA.

Experimental diets were prepared by incorporating betaine hydrochloride at four graded levels namely 0.25g, 0.5g, 0.75g and 1.0g/100g feed into Coppens fish feeds (0.2 – 0.5mm). Diet without betaine additive i.e. 0.0g/100g feed served as the control and coded as T_0 (0.0g), T_1 (0.25g), T_2 (0.5g), T_3 (0.75g) and T_4 (1.0g) respectively). The betaine hydrochloride was included at the measured quantity for each diet and was diluted into 10 ml of warm water to form a solution. The solution was sprayed onto the Coppens fish feeds (0.2 – 0.5mm). The betaine hydrochloride additive Coppens fish feeds (0.2 – 0.5mm) were prepared in 100g each time.

Experimental Design

Each treatment was applied to 100 fry (each weighing 0.26±0.0g) in triplicate making a total of 15 plastic hatchery tanks (semi flow - through system). Water quality parameters monitored includes; pH, dissolved Oxygen (DO), temperature and ammonia. Fry were fed at a fixed feeding rate of 5% body weight 4 times daily between the hours of 07:00 and 23:00 at regular interval for a period of 28 days. The initial body weight of each set of fry was measured using a digital weighing balance before stocking and subsequently bulk weighing of fry in each tank was done after every 7 days, the growth response parameters were computed and analysed according to the following equations as described by Stickey *et al.* (2006).

$Mean\ weight\ gain\ =\ \text{final weight (g)} - \text{initial weight (g)}$

$Daily\ weight\ gain\ =\ \text{final weight (g)} - \text{initial weight (g)/experimental days}$

$SGR = \{(log\ \text{final weight (g)} - log\ \text{initial weight (g)})/\ culture\ period\} \times 100$

$\text{FCR (g/g)} = \text{feed intake (g)/weight gain (g)}$

$Survival\ rate = (final\ no.of\ fish/initial\ no.of\ fish) \times 100$

Statistical Analysis

The data obtained were subjected to one - way analysis of variance (ANOVA) using the GraphPad instant package for windows 2010 of Statistical Analysis System (SAS, 2010). Mean separation was done (at P = 0.05) using Fisher's least significance difference (LSD) to separate the means in cases of significant difference.

RESULTS AND DISCUSSION

The proximate composition of the Coppens fish feeds (0.2 – 0.5mm) fed to the *Clarias gariepinus* fry is presented in Table 1. All the diets contain 49% crude protein, 12% crude lipid, 6.0% crude fibre, 8.0% ash, 1.5% calcium, 8.0% moisture and 1.5% phosphorus.

Table 1: Proximate Composition of Coppens Fry Feeds (0.2 – 0.5 mm) Used for the Study

Nutrients	Percentage (%)
Crude protein	49
Crude lipid	12
Crude fibre	6.0
Ash	8.0
Calcium	1.5
Moisture	8.0
Phosphorus	1.5

Data on the growth response of the *Clarias gariepinus* fry fed different levels of dietary betaine hydrochloride are given in Table 2. There was significant difference amongst the fry fed treatment diets in terms of MWG, DWG, SGR and FCR. The highest growth response in terms of MWG (2.34±1.02g/fish), DWG (0.083±0.09 g/day) and SGR (3.57±0.11 %/day) were recorded from the fry fed betaine incorporated diet at 0.5g/100g feed T_2. Similarly, the least (best) FCR (0.155±0.04) was recorded from the fry fed diet T_2. The highest survival rate (88.9±1.07%) was recorded from the fry fed diet T_2. There was no significant difference in terms of the survival rate of the treatment diets. During the experimental period, the water quality parameters monitored such as the

water temperature, pH, dissolved oxygen and ammonia were within the recommended range for *Clarias gariepinus* culture.
Growth response such as the MWG, DWG and SGR were highest in the fry fed diet T_2 which was in agreement with the findings of Sogbesan *et. al.* (2022) who reported a similar result for *Clarias gariepinus* fingerlings fed dietary betaine additive diets and Ali (2022) for *Clarias gariepinus* juveniles fed different levels of dietary betaine additive diets. The FCR was least (best) in the fry fed diet T_2 containing betaine additive at 0.5g/100g feed which was in consistent with the findings of Ekasari *et al.* (2021) who reported a similar result for *Epinephelus lanceolatus* × *Epinephelus fuscoguttatus* juvenile fed dietary betaine additive at 0.5g/kg feed and Sogbesan *et. al.* (2022) who reported a similar result for *Clarias gariepinus* fingerlings when betaine additive was added to the diet at 0.5g/100g feed.
The highest MWG, DWG, SGR and the least (best) FCR recorded from the fry fed diet T_2 containing betaine additive at 0.5g/100g feed indicated that the betaine additive has a beneficial effect when added to the diet at optimal level but, below or beyond that level may negatively affect the catabolic activity and was in support with the findings Leong - Seng *et al.* (2019) who reported a similar result for *Epinephelus fuscoguttatus* fingerlings fed betaine additive diet.
The high survival rate values recorded from all the treatment diets used in this study indicated that the diets were well tolerated by the fry and also the water quality parameters were not affected by the incorporation of betaine hydrochloride into the diets.

Table 2: Growth Response of *Clarias gariepinus* Fry to Treatment Diets

Parameters	T_0	T_1	T_2	T_3	T_3
Initial mean weight (g/fry)	0.26 ± 0.0^a	0.26 ± 0.0^a	0.26 ± 0.0^a	0.26 ± 0.0^a	0.26 ± 0.0^a
Final mean weight (g/fry)	1.81 ± 0.11^a	1.83 ± 0.16^a	2.60 ± 1.33^b	1.86 ± 0.18^a	1.88 ± 0.19^a
Mean weight gain (g/fry)	1.55 ± 0.02^a	1.57 ± 0.06^a	2.34 ± 1.02^b	1.60 ± 0.82^a	1.62 ± 0.05^a
Daily growth rate (g/day)	0.055 ± 0.03^a	0.083 ± 0.09^b	0.056 ± 0.02^a	0.057 ± 0.01^a	0.058 ± 0.05^a
Specific growth rate (%/day)	3.00 ± 0.18^b	3.02 ± 0.12^b	3.57 ± 0.11^c	3.05 ± 0.03^b	3.06 ± 0.09^b
Feed conversion ratio (g/fry)	0.234 ± 0.02^a	0.231 ± 0.01^a	0.155 ± 0.04^b	0.227 ± 0.03^a	0.224 ± 0.07^a
Survival rate (%)	88.6 ± 1.02^a	88.0 ± 1.01^a	88.9 ± 1.07^a	88.3 ± 1.04^a	88.1 ± 0.06^a

Mean values in each row with similar superscripts are not significantly different ($p>0.05$).
Keys:
T_0 - Betaine (0.0g/100g)
T_1 - Betaine (0.25g/100g)
T_2 - Betaine (0.5g/100g)
T_3 - Betaine (0.75g/100g)
T_4 - Betaine (1.0g/100g)

CONCLUSION AND RECOMMENDATION

Findings from this study indicated that when betaine hydrochloride was used as additive in the diet of fry of *Clarias gariepinus* it promoted desired growth response of the fry. Betaine hydrochloride at inclusion level 0.5g/100g feed tends to be more significant in many parameters, hence, it is recommended.

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DETERMINATION OF FATTY ACIDS COMPOSITION OF CRAB (P*ORTUNUS TRITUBERCULATUS*) OBTAINED FROM LAGOS COASTAL WATER USING GC-MS CHROMATOGRAPHY

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ABSTRACT
The present study aimed to determine the fatty acid composition of crab (Portunus trituberculatus) obtained from Lagos coastal water using GC-MS chromatography. A total of 14 Fatty acids were identified, with Vaccenic acid and Palmitic acid being the most abundant. The Total Saturated Fatty acid (SFA) content was found to be (26.83%), while the Total Monounsaturated Fatty Acid (MUFA) and Total Polyunsaturated Fatty Acid (PUFA) contents were (29.03%) and (36.18%) respectively. The Omega-3 (ω-3) Fatty Acid Content was found to be (36.18%), while Docosahexaenoic Acid (DHA) and Eicosapentaenoic Acid (EPA) being the major contributors. The Omega-6 (ω-6) Fatty Acid Content was found to be (5.73%), with Arachidonic acid being the major contributor. The values obtained for the PUFA to SFA was in the ratio of 1:35. The results of this study suggested that Portunus trituberculatus collected from Lagos coastal water is a good source of SFA, MUFA, PUFA, and ω-3 and ω -6 fatty acids, which are essential for maintaining human health.
Keywords: *Portunus trituberculatus, Fatty acids, Vaccenic acids, Palmitic acids, Saturated, Monounsaturated, polyunsaturated Fatty acids.*

INTRODUCTION
Fatty acids are the building blocks of the fat in our bodies and the food we eat. During digestion, the body breaks down fats into fatty acids, which can then be absorbed into the blood. They are classified as carboxylic acids with hydrocarbon chains spanning from 4 to 24 carbon atoms, which makes up the majority of lipids. It can be completely saturated (no double bonds on the hydrocarbon chain) or mono- or poly-unsaturated (one or more double bonds on the hydrocarbon chain). The melting point and solubility of fatty acids and/or the compounds that contain them are largely determined by the length and degree of unsaturation (number of double bonds) of the hydrocarbon chain (Dunbar *et al*., 2014). Many studies have been conducted over the years to examine the impact of various dietary lipid sources on aquatic animal growth, physiology, metabolism, welfare, and product quality (Yuan *et al*., 2020). The quality of farmed aquatic animals has a considerable impact on consumer preferences and purchasing behaviors, ultimately influencing the success or failure of farming organizations (Hardy and Lee, 2010). This is assessed by a combination of nutritional value (e.g., protein, amino acid, fatty acid, vitamin, and mineral content) and sensory quality (e.g., skin or fillet color, texture, flavor, and odor) of the edible component (fish fillet or crab/shrimp flesh) (Yuan *et al*., 2020).
Essential fatty acids are lipids that the human body cannot synthesize and are mostly composed of omega 3 (ω-3) and omega 6 (ω-6) fatty acids, which are polyunsaturated fatty acids (PUFAs). These PUFAs (ω-3 and ω-6) are defined by the number of carbons from the Fatty Acid methyl terminal for the first double bond (Dunbar *et al*., 2014). The ω -3 are primarily Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA), whereas the ω -6 are primarily linoleic acid (LA) and are required in varying proportions in the human diet. In the human diet, fish is the primary source of long-chain ω-3 fatty acids (Watters *et al*., 2012). These PUFAs have several advantages and are also known as biological regulators of human health problems (Deckelbaum and Torrejon, 2012; Dunbar *et al*., 2014; Watters *et al*., 2012).
The swimming crab, *Portunus trituberculatus*, is a popular and widely distributed marine crustacean in China, Japan, and Korea, where it is consumed and employed as a raw material in the processing industry (Han *et al*., 2018; Hao *et al*., 2021). Swimming crabs are widely known for their excellent nutritional value, which includes an abundance of highly unsaturated fatty acids (PUFA) (Jin *et al*., 2013). Therefore, this study seeks to Evaluate

the fatty acid composition of crab (*Portunus trituberculatus*) fished along Lagos coastal water using GC-MS chromatography.

MATERIALS AND METHODS

Sources of Materials/Equipment

The Raw sample used in this study the *Portunus trituberculatus* tissues was obtained from Lagos coastal water Lagos Nigeria. The samples were separately packed in a clean polythene bags and transported in ice boxes prior to analysis while the Analytical grade chloroform/methanol (2:1 v/v), distilled water and rotary evaporator were obtained from the Chemistry Laboratory of the Institute for Oceanography and Marine Research. (NIOMR) Lagos state.

Method of Sample Preparation

The samples (Crab tissues) were washed with distilled water and the edible muscle part was removed using a sharp forceps and homogenized with a mixer grinder. Homogenized samples were packed in sealed polythene bags, labeled properly and stored under a freezer for further analysis. The lipids in the muscle tissue were extracted using the method described by Bligh and Dyer, 1959. Lipid content was determined as a percentage value using the gravimetric method. The extract was used to generate the fatty acid methyl ester (AOCS Method c2.66).

Gas Chromatography equipped with mass spectrometer were employed (GC-MS) with FTD Detector (GC-MS-QP2010SE Shimadzu; Japan) analysis was conducted using 1-µL split injections onto a 105 m (fused silica) DB wax column (Restek, PA). The initial column temperature was held at 100°C for 4 min, before being increased to 240°C at a rate of 3°C min^{-1}. The injector temperature was held constant at 225°C and the detector temperature was 285°C. Helium was used as the carrier gas and column flow was held at 1 mL min^{-1}. The calibration curve was constructed using the FAME (Larodan, Sweden). Heptadecanoic acid was added to each and every sample as an internal standard

RESULTS AND DISCUSSION

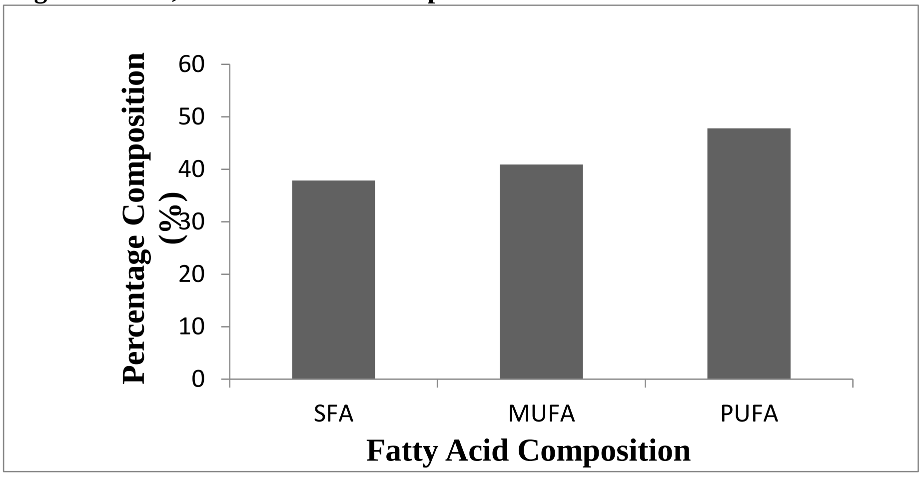
The profile and percentage composition of the fatty acid present in *P .trituberculatus* meat were analyzed using GC-MS techniques and 14 different fatty acids were identified as shown in Table 1. The total composition of the SFA, MUFA, and PUFA are presented in Figure 1. From Table 1, Vaccenic acid 18:1(ω- 7) was the most predominant with 10.62% followed by palmitic acid 16:0 (9.81%), heptadecanoic acid 17.0 (9.41%) docosahexaenoic acid (DHA) 22:6 (ω -3) (9.11%), then oleic acid 18:1(ω- 9) (8.60%), while myristic acid and tridecanoic acid were 3.0% and 4.54% respectively. The findings also indicated that PUFA is the predominant compound among the investigated fatty acids SFA, MUFA, and PUFA. These PUFAs are likely to be useful in preventing or reversing some of the side effects of retroviral drugs, its direct intake also alters the cell membrane, which in turn modulates cell/ tissue response to infection, injury, and inflammatory actions (Dias, 2006).A higher ratio is considered the most beneficial for human beings. However, the higher content of the (ω -6) PUFAs may lead to many inflammatory diseases (Simapholous, 2002). Therefore Food and Agricultural Organization and the World Health Organization (WHO) of the United Nations have recommended the dietary(ω -3) to (ω -6) PUFA ratio should at least be 0.1 to 0.2 (Wu *et al*.,2010). *P. trituberculatus* shows the (ω -3) to (ω -6) ratio as 1.35 therefore, the edible muscle part of the crab may be considered a healthy seafood item.

Table 3: Percentage Composition of Free Fatty Acid in the Muscle Tissue of *P. trituberculatus* (Crab).

Fatty acid composition of *P. trituberculatus* muscle.	The number of carbon chains	Percentage (%) composition
Tridecanoic acid	13	4.54
Myristic acid	14	3.0
Pentadecanoic acid	15	5.47
Palmitic acid	16	9.81
Heptadecanoic acid	17	9.41
Stearic acid	18	4.41
Oleic acid	18:1	8.60
Vaccenic acid	18:1	10.62
Linolenic acid	18:3	5.11
Eicosenic acid	20:1	1.87
Arachidonic acid	20:2	5.73
Eicosapentanoic acid	20:5	9.11
Eicosadienoic acid	22:4	5.81
Dicosahexanoic acid	22:6	8.55
SFA		26.83
MUFA		29.03
PUFA		36.18

(ω 3)	30.44
(ω- 6)	5.73
(ω-7)	10.62
(ω-9)	8.60
PUFA/SFA	1.35

Figure 1: SFA, MUFA and PUFA in portion of *P. trituberculatus* muscle



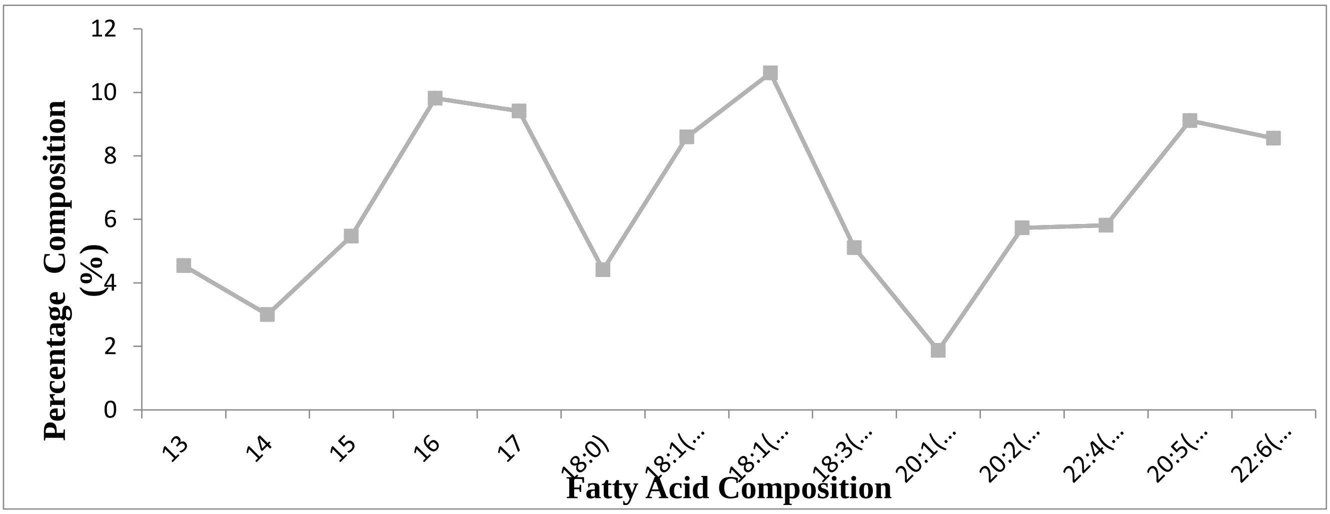


Figure 2: Percentage fatty acid composition of *Portunus trituberculatus*

CONCLUSION

This study was conducted on the fatty acids composition of *Portunus trituberculatus* crab collected from Lagos coastal water using GC-MS chromatography technique which provides valuable insights into the nutritional value of this crab species. The study found that this crab species is a rich source of essential fatty acids such as SFA, MUFA, and PUFA and both ω -3 and ω- 6 fatty acids. The high content of omega-3 fatty acids, specifically (DHA) and (EPA), in this crab species makes it a particularly beneficial enhancer of healthy unsaturated fatty acids as addition to a healthy diet.

Conclusively, the results obtained from this study provided a valuable information /data on the importance of addition and consumption of sea foods such as crab in human diet which are major sources of essential fatty acids that helps to lower risk of heart disease thereby improving our overall health and well-being.

RECOMMENDATION

From the findings in this research work, it can be recommended that,

1. The tissue of Crab (*P. trituberculatus)* is a good source essential fatty acids that are important for lower risk of heart disease because it contains saturated fatty acid, monounsaturated fatty acid and poly unsaturated fatty acid which are essential for maintaining human health condition. The high content of

omega-3 fatty acids in this crab species may be particularly beneficial for maintaining cardiovascular health and reducing inflammation in the body.

2. Further analysis can be evaluated on the fatty acids profile of the samples.

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Federal University of Lafia, Nasarawa State

"LAFIA"

SUB-THEME 10:

Strategies for Multi-dimensional Approach to Livestock Development

EFFECTS OF FEEDING GRADED LEVELS OF FERMENTED AFRICAN LOCUST BEAN (*PARKIA BIGLOBOSA*) SEED MEAL (FALBM) ON INTERNAL AND EXTERNAL EGG QUALITY TRAITS OF BOVAN'S BROWN LAYERS

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ABSTRACT

An experiment was conducted to test the effects of replacing groundnut cake with fermented African locust bean (Parkia biglobosa) seed meal (FALBM) on egg quality traits of Bovan Brown layers. A total of 180 Bovan's Brown layers of 30 weeks of age were allotted into five dietary treatments in a completely randomized design (CRD) comprising 3 replicates per treatment. FALBM was incorporated at 0, 25, 50, 75 and 100% (as diets A, B, C, D and E respectively) replacement levels as an alternative source of protein to groundnut cake. The birds were housed in battery cages measuring 40cm length, 35cm width and 40cm height and fed the experimental diets for a period of 42 days. The data generated from the experiment were subjected to analysis of variance (ANOVA) and significant (P<0.05) differences among treatment means were compared using Duncan's multiple range test. The results of egg quality parameters revealed that diets had no significant (P>0.05)effect on all the parameters measured, except for egg weight (67.6g for birds fed diet A and 65.83g for birds fed diet E) and yolk weight (18.41g for birds fed diet A and 16.71g for birds fed diet C) which were significantly (P<0.05) differently across the treatments means. The values obtained for egg weights ranged from 67.61 to 65.83g/egg, birds on control diet (A) was significantly higher (P<0.05) compared with other treatments means. Similarly, the values obtained for yolk weight showed that birds fed diet A (control) had the highest (P<0.05) value (value of the yolk weight and unit, please) while birds fed diet D presented the least (value of the yolk weight and unit, please). It is therefore recommended that experiment with different processing methods should be done in order to ascertain the effects of processing on the nutritional value of African Locust Bean.

INTRODUCTION

Poultry eggs are one of the most attractive targets for nutrition manipulation, owing to the extraordinary sensitivity of most of its traits to dietary factors. Varied and special nutritional approaches are developed targeting the specific properties of eggs (Wang *et al*., 2017). The quality traits of an egg are parameters that affect its acceptability to the consumer (Duman *et al*., 2016). The first concern of egg quality modulation is to reduce the defects of eggs, either on appearance or on flavor/taste (Wang *et al*., 2017).

Evaluation of egg quality parameters is essential both for table eggs and for the production of hatching eggs (Rotimi *et al*., 2022). The egg size and internal quality of eggs are important for both table and hatching eggs (Alkan *et al*., 2013).There are studies on the relationship between egg weight and egg quality parameters (Olawumi and Ogunlade, 2008; Sarica *et al*., 2012). As for the poultry industry, egg production is now hampered by a heavy shortage of feed ingredients (Wang *et al.*, 2017). Additionally, to meet the severe challenge, the egg industry should inevitably develop in a more sustainable way, aiming to maximize production at the lowest cost and slightest environmental impacts (Godfray *et al.,* 2010). The high cost of animal protein has directed interest towards several leguminous seed proteins as potential sources of vegetable protein for human food and livestock feed. Among the plant species, grain legumes are considered as the major source of dietary proteins. They are consumed worldwide, especially in developing and under developed countries where consumption of animal protein may be limited as a result of economic, social, cultural or religious factors (Esenwah and Ikenebomeh, 2008).

These sources of conventional feed ingredient are more expensive and not readily available to all producers at all locations due to competing demand for the commodity between man and livestock, adverse climatic condition and the use of these ingredient in the biofuel industry (Iji *et al.,* 2011). This stimulated the search for alternative feed ingredient particularly protein sources for poultry.Among these alternatives is African locust bean seed which is rich in protein and is used as a flavorintensifier for soups and stew. According to Omafuvbe *et al.,* (2004), its crude protein content is similar to other beans like cowpea, jack beans, lima beans and pigeon pea. It is a rich source of essential amino acid**s,** minerals and vitamins.

Improved performance traits, nitrogen retention and feed utilization of broilers fed fermented African locust beans as a replacement of groundnut cake have been reported by Kolo (2000); Ayanwale and Ari (2002) and Dawodu (2009). It is therefore on this positive attribute that this study was therefore carried out to assess the egg quality of laying chickens fed fermented African locust beans a substitute for groundnut cake. The aim of this experiment was to evaluate the possibility of composing a diet with a replacement of FALBM up to100% to groundnut cake in the diets feedingredients as major source of protein. The experiment compriseda 30 weeks of age production period with egg quality analysis and evaluate the cost benefit of using FALBM in the formulation of the experimental diet.

MATERIALS AND METHODS

Experimental Site and Location

The study was conducted at Sensor farm. The farm is located at DanladiNasidi housing estate in Kumbotso Local Government Area of Kano state between June 2019 and May 2020. The area is located within latitude of coordinate 11^0 88 'N and 8^0 50, E and longitudes 11^0 53 N and 8^0 30 E. Kano is bordered with Kaduna state on the South west, Bauchi state in south east, Katsina state in the north west and Jigawa state in the north east. (Dakata andYelwa, 2012). The area is characterized with tropical wet and dry seasons (Olofin, 1987) a wet season (May-September) and dry season (October - April). The annual rainfall and temperature ranges between 886mm and 960 and 21^0Cand 46^0C, respectively and humidity ranges between 20-40% (dry Season) and 60-80% (wet season) (KNARDA, 2006).

Source of Experimental Feed Ingredients and Formulation of the Diet

Ingredient for the formulation which include maize, groundnut cake, limestone, wheat offal, fish meal and bone-meal were purchased from feed raw material market at TafawaBalewa road Kano. African locust bean was purchased from makole mark*et al*ong Maiduguri road while lysine, methionine and Vitamin/ mineral premix were purchased from Animal Care Services Consult limited Kano.

The ingredients were milled by local feed millers using hammer mill and mixer. The experimental diets were formulated to contain different levels of fermented African locust as an alternative protein source to groundnut cake as shown in Table 1.

Processing and Fermentation of Locust Bean Seed

Eighty kilograms (80kg) of locust bean seed was cleaned, washed and poured into a container containing 200 liters of boiled water. It was allowed to soak for 24 hours, excess water was later removed and allowed to ferment for 3 days in an air tight polythene bags. Fermented seeds was then removed after 3 days and spread on a polythene bags to be sun dried for 3 days.

Experimental Birds and Their Managements

A total of one hundred and eighty 180 Bovan's Brown layerchickens of 30 weeks of age were used in the experiment for a period of six weeks. The birds were housed in battery cages measuring 40cm length, 35cm width and 40cm height. The house waswell ventilated, in an east-west orientation. The birds were fed commercial layer mash prior to the commencement of the experiment at 30 Weeks of age and were earlier vaccinated against common poultry diseases Newcastle, infectious bursal disease, coccidiosis, fowl pox, infectious bronchitis and egg drop syndrome. A known quantity of feed and water was provided *ad libitum* throughout the experimental period.

Source of Experimental Birds

A total of 180Bovan's Brown layers were purchased from Sovet International Limited at Tarauni, Kano.

Treatments and Experimental Design

The experiment was laid in a completely randomized design (CRD) as outlined by Steel and Torrie (1980). The birds were allotted to 5 groups of different levels of inclusion of fermented African locust beans and each group was replicated three times with 12 birds per replicate. FALBM was incorporated at 0, 25, 50, 75 and 100% as an alternative source of protein to groundnut cake.

Table 1: Composition of the Experimental Diets

Ingredients	Diet (FALBM %)				
	A(0)	B(25)	C(50)	D(75)	E(100)
Maize	43.00	42.00	43.00	41.00	42.00
Groundnut cake	16.00	12.00	8.00	4.00	0.00
Maize bran	7.00	8.00	7.00	8.00	7.00
Wheat offal	17.00	17.00	17.00	18.00	18.00
FALBM	0.00	4.00	8.00	12.00	16.00
Fish meal	5.00	5.00	5.00	5.00	5.00
Bone meal	3.50	3.50	3.50	3.50	3.50
Limestone	8.00	8.00	8.00	8.00	8.00
Salt	0.25	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10	0.10
Total	100	100	100	100	100
Calculated Analysis (%) - Unless otherwise stated					
ME (kcal/kg)	2534.90	2527.90	2539.70	2517.14	2528.90
Crude protein	17.19	17.20	17.80	17.27	17.26
Crude fibre	4.10	4.26	4.20	4.45	4.40
Ether extract	3.70	3.60	3.50	3.40	3.30
Calcium	3.65	3.65	3.65	3.65	3.65
Phosphorus	0.47	0.45	0.48	0.44	0.46

ME=Metabolizable Energy.
FALBM= Fermented African Locust Bean Meal.
Premix=Vitamin Mineral Mixture.

**2.5kg of premix supplied vitamin A 12500 I. U. Vit-D3 2500 I. U. Vit E-500mgL- Vit K3. 2.5mg; Vit B1, -3.0mg: Vit B2 6.0MG; Vit B6 6.0mg: Niacin 40.0mg; calcium pantothenate 10.0mg; Biotin 0.80mg; Vit B12 0.25mg; Folic acid 1.0mg; Choline Choride 300mg; manganese 100mg; Iron 50mg; Zinc 45; Copper 2.0mg; cobalt 0.25mg; iodine 1.55mg, selenium 120mg.

Data Collection

Data were collected after seven days adaptation period. Feed intake, egg production, minimum and maximum temperature, humidity and mortality were monitored on daily basis, while egg quality was monitored weekly bases, and cost of feed per egg.

Egg Quality Assessment

After four weeks of the experiment, two fresh eggs were randomly selected from each replicate for external and internal quality assessment for 3 consecutive days. Each egg was weighed and broken into a Petri Dish with a knife and the yolk was separated from the albumen using a yolk separator. Albumen and yolk weights were measured using a sensitive electronic scale to the nearest 0.0lg. Shell thickness was measured with the aid of micro meter screw gauge (Panda *et al*., 2003).

Egg shell weight was determined after emptying the egg contents. The shell interior was cleaned with a tissue paper and allowed to dry, thereafter the weight was taken using a sensitive scale. The color of yolk was scored visually with the aid of the Roche Colour fan (numbered from 1-15, indicating very light to orange colouration), the colour fan was placed near the yolk to determine the colour that matches the yolk and colour number was noted. The length of the egg was measured using vernier calliper between the pointed end and the broad end. Similarly, width of the egg was taken at the widest point.

Chemical analysis

The samples of the experimental diets, raw and fermented African locust bean were properly ground and labeled at the animal science laboratory Bayero University Kano. They were then subjected to proximate analysis to determine the nutrients (CP, CF, EE, Ca and P) compositions according to procedures as outlined by AOAC (1990). The Concentrations of trypsin inhibitor, tannin and phytate were determined using the procedural methods as outlined by Liener (1979), Dawra *et al.* (1988) and Maga (1983), respectively

Feed Cost

Costs of experimental feed ingredients were taken in accordance with the prevailing price during the formulation of the experimental diets. The cost of each experimental diet, the average cost of actual feed consumed (₦ /kg) and the cost of the feed/ egg (₦/egg) were calculated by using the cost of each ingredient (₦) used in the diet formulation.

Statistical Analysis

The data generated from the experiment were subjected to analysis of variance (ANOVA) using SAS (1999) statistical package. Significant differences between the means were determined using Duncan's multiple Range Test (Duncan, 1955).

RESULTS

Proximate Composition of the Experimental Diets Fed Graded Levels of FALBM

Result of the proximate composition of the experimental diets fed to layer chickens is presented in Table 2. The result showed dry matter ranged from 89.86 – 95.30%, Diet A had the highest value while diet E presented the lowest value for dry matter. The trend indicated that dry matter decreased at increasing inclusion levels of FALBM. Values recorded for crude protein ranged from 15.66 – 16.38 %, ether extract ranged from 2.33-3.16%, and crude fiber ranges from 4.43-4.56% while the ash contents ranged from 4.25-5.47%. The trend for the above proximate components decreased with increasing levels of FALBM for dry matter, crude protein, ether extract and nitrogen free extract. Mean while the values increase with increasing increase levels of FALBM for crude fiber and ash contents.

Table 2: Proximate Composition of Experimental Diets

	Diets (FALBM %)				
Parameter	A(0)	B(25)	C(50)	D(75)	E(100)
DM	95.30	94.06	92.93	92.06	89.86
CP	16.38	16.23	16.13	16.05	15.66
CF	4.43	4.53	4.53	4.56	4.56
EE	3.16	2.81	2.56	2.41	2.33
NFE	67.30	65.28	64.50	63.65	63.04
Ash	4.25	4.80	5.18	5.18	5.47

DM: dry matter, CP: crude protein, CF: crude fiber, EE: ether Extract, NFE: nitrogen free extract FALBM: Fermented African locust bean meal.

Effect of feeding graded levels of FALBM on egg quality parameters of layer chickens.

Table 3 contains the effect graded levels of inclusion FALBM on egg quality. The results shows no-significant (P>0.05) differences in all the parameters measured, except for egg weight and yolk weight which were significantly (P>0.05) different across the treatment means. Values for egg weight showed that birds fed diet A had significantly (P<0.05) highest value compared to other treatment means. The values for birds fed diet A were statistically (P>0.05) similar with birds fed diet B. Values obtained for birds fed diet B is statistically similar birds fed diet C and D while birds fed diet E had values that are statistically (P>0.05) similar with birds fed diet C and D. Yolk weight values showed that birds fed diet A had significantly (P<0.05) highest value compared to other treatment means. Birds fed diet A were statistically (P>0.05) similar with birds fed diet B. Values obtained for birds fed diet B ~~is~~ are statistically similar with birds fed diet C, D and E.

Table 3: Effects of graded levels of FALBM on egg quality parameter

	Diets (FALBM %)						
Parameters	A(0)	B(25)	C(50)	D(75)	E(100)	SEM	P value
Egg weight(g)	67.61^{a}	66.89^{ab}	65.94^{bc}	65.94^{bc}	65.83^{c}	0.47	0.000
Yolk weight(g)	18.41^{a}	17.96^{ab}	16.72^{b}	16.69^{b}	16.71^{b}	0.45	0.001
Albumen weight(g)	27.21	27.19	26.56	25.90	25.57	0.63	0.061
Egg length(mm)	54.30	54.13	48.90	55.18	54.39	3.69	0.474
Egg diameter(mm)	42.81	42.85	42.23	42.99	42.99	0.34	0.234
Shell thickness(mm)	1.07	1.03	1.03	1.06	1.08	0.14	0.659
Yolk colour	2.89	2.78	2.89	2.11	2.89	0.34	0.234

^{a,b,c,d} Means in the same row with different superscript are significantly different(P<0.05), FALBM: Fermented African locust bean meal, SEM: standard error of mean.

Cost of Diets Formulated

The cost of 100 kg of each of the experimental diet revealed a constant decrease from ₦9, 635in diet A to ₦9, and 235 in diet E. The cost of maize is higher in diet A and C (₦4300) followed by ₦4200 for B and E. diet D has the least cost of maize (₦4100). The cost ground cake in 100 kg of the experimental diets was constantly decreasing from N2080 in diet A to ₦520 in diet D. Diet E had zero cost of ground cake. On the other hand, the cost FALBM increased from ₦440 in diet B to ₦1760 in diet E. Diet A had zero cost of FALBM. Other ingredients like fish meal, bone meal, lime stone, salt, premix, lysine and methionine were all constant from diets A to E.

Table 4: Cost analysis of layer chickens fed graded levels of fermented African locust bean meal

	Diets (FALBM %)				
Parameter	**A(0)**	**B(25)**	**C(50)**	**D(75)**	**E(100)**
CED(₦)	9632	9485	9465	9250	9235
CF/kg(₦)	96.32	94.85	94.65	92.50	92.35

CED: Cost of experimental dietCF/kg: cost of feed/kilogram.

DISCUSSION

The proximate composition of experimental diets of layer chickens fed graded levels of FALBM indicated that dry matter content decreased as the levels of FALBM was increased. All the parameters including crude fiber and ash increased as the level of the FALBM were increased while dry matter, crude protein, ether extract and nitrogen free extract decreases as the levels of FALBM increases in the diets. The decrease in dry matter, ether extract and nitrogen free extract and increase in ash and crude fiber content of the diet could be due inclusion levels of FALBM in the treatment diets. The results obtained for dry matter, ether extract and nitrogen free extract in this study is in line with the work the of Akanji*et al*. (2015) who evaluated egg laying performance and blood chemistry of birds fed fermented and unfermented African locust beans diets. The results obtained for crude protein in this study contradict the feedings of Akanji*et al*. (2015) who reported increase in crude protein content of FALBM. The difference in crude protein content could be due to period of boiling and sources of African locust bean meal.

The results of egg quality parameters revealed no-significant (P>0.05) differences in all the parameters measured, except for egg weight and yolk weight which were significantly (P<0.05) different across the treatments means. This is an indication that FALBM has no detrimental effect on egg shell formation. The observation is in agreement with ~~the~~ earlier reports of ~~(~~Babangida and Ubosi~~,~~ (2006)~~;~~ and Bawa~~,~~ (2011) who reported no significant difference (P>0.05) in the egg shape index of Japanese quails fed graded levels of dietary protein.

Effect of graded levels of FALBM in diet of laying chickens on egg quality parameter revealed significant differences in mean egg weight and yolk. The lower egg weight and yolk weight obtained for birds in treatment 5 could be due to the increased level of FALBM in the diet. This could be due to lower levels of crude protein and nitrogen free extract of diet compared with other diets as revealed by the proximate composition of the experimental diets. Novak *et al*., (2008) revealed that Lowering CP in laying hen diets reduced egg weight through the period 18-60 weeks-old. Summers *et al*. (1991) and Lopez and Leeson (1995) also reported that layer egg weight is strongly related to the content of CP in the diet.

The result indicates lower cost in FALBM base diets compared with the control. This is due to the relatively lower cost of FALBM to groundnut cake at the period when the ingredients where purchased. The lowest cost (₦ 92.35) per kg of diet obtained in this study is higher than (₦ 72.86/unit) per kg diet obtained by Tamburawa *et al*. (2017) who evaluated the effect of soaked and fermented African locust bean seeds meal on the performance, organs and carcass characteristics of broiler chickens. This could be due to the seasonal variation in the price of ingredient.

CONCLUSION AND RECOMMENDATIONS

It was concluded that replacing groundnut cake with fermented African locust bean (*Parkia biglibosa*) seed meal (FALBM) appeared to have no positive influence on the egg quality of Bovan's Brown layers. However, the inclusion of FALBM had positive influence on the total cost of the experimental diet, from A (25%) to E (100%) FALBM replacement levels.

Based on this research it is recommended thatfermented African locust bean meal can be incorporated up to 25% in the diet of layer chickens without any deleterious effect. Meanwhile, further research should be conducted in which another method of processing African locust bean should be used in order to better enhance it utilization by layer chicken.

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PREVALENCE OF BRUCELLOSIS IN SOME SETTLED CATTLED FARMS IN DAURA LOCAL GOVERNMENT AREA, KATSINA STATE, NIGERIA

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ABSTRACT
Serological study was conducted to determine the prevalence of brucellosis in some settled Cattle Farms in Daura Local Government Area, Katsina State, Nigeria. A total of 500 cattle sampled sera from 6 Farms across ages breeds and sexes were collected and examined for antibodies against Brucella species using Rose Bengal plate test (RBPT). Information about the Sex, Age, and Breeds of Cattle were collected using structured questionnaire. Association between prevalence of the disease and Age, Sex and Breeds of cattle were determined using Chi-square Statistics. The result obtained revealed the overall prevalence of 35 (7%). The highest prevalence was observed in cattle aged between 4-6 years old, 18 (3.6%) while the least prevalence of 1 (0.2%) was recorded in cattle aged above 9 years. Based on sex, the infection was higher in Female 22 (4.4%) than male 13 (2.6%). There is a significant association between the prevalence of Brucellosis and the sex of cattle at ($P \leq 0.05$). However, there is no significant association between prevalence of the disease, the age and breeds of Cattle examined. The study confirmed the presence of brucellosis in the study area and cattle in the screened farms were likely to transmit the disease to humans and other susceptible animals. It is recommended that all the infected animals should be immediately restricted, and treated or culled to avoid further spread of the infection. Susceptible animals should be vaccinated and Public should be enlightened about the zoonotic aspect of the disease.
Keywords: *Brucellosis, Cattle, prevalence, RBPT*

INTRODUCTION
Brucellosis is an infectious, contagious disease primarily of Animals caused by a number of host-adapted species of the Gram-negative intracellular bacteria of the genus *Brucella*. The disease is one of the most widespread zoonoses in the world (Munir *et al.*, 2010). It is one of the most devastating trans-boundary animal diseases and also a major trade barrier and economically very important as a major cause of losses in the livestock industry (Gul and Khan, 2007). Brucellosis infection is widespread globally and is endemic in many developing countries including Nigeria and it has been reported in various parts of the country and in various animal species and in humans (Mai *et al.*, 2018; 2012; Saleh *et al*., 2016; Cadmus *et al*., 2006; and Kudi *et al*., 2015). In a large seroprevalence survey of brucellosis in cattle herds under diverse production systems in northern Nigeria, Mai *et al*. (2012) reported a significantly higher seroprevalence of Brucellosis in cattle with the overall level of 37% using RBPT and 26.3% after confirmation with c-ELISA. Many cases have been reported in various literatures (Agada *et al*., 2017; Adamu *et al*., 2016; Saleh *et al*., 2016).
The disease is well known for its effects on decreasing productivity of infected livestock by causing abortions, reducing fertility and decreasing milk yield, resulting in substantial economic losses (Nicoletti, 1980). Other symptoms that characterised the disease include; sterility, in bulls still birth, and retained placenta, in females orchitis, hygroma and epididymitis in males (Adams, 2002). However, the rare symptoms like mastitis, repeat breeding and joint ill were also reported (Chakravarty *et al.*, 2007). There is an occupational risk to veterinarians, abattoir workers and farmers who handle infected animals/carcasses and aborted fetuses or placentas. Brucellosis is also one of the most easily acquired laboratory infections (OIE, 2006).
Yagupsky and Baron (2005) reported that *Brucella* infection is readily transmissible to humans, causing acute febrile illness – undulant fever – which may progress to a more chronic form and can also produce serious complications affecting the musculo–skeletal, cardiovascular, and central nervous systems. If not treated at the acute stage. Infection is often due to occupational exposure and is essentially acquired by the oral, respiratory, or conjunctival routes, but ingestion of dairy products constitutes the main risk to the general public. The incidence

of the disease in human is thus closely tied to the prevalence of infection in sheep, goat and cattle and to practices that allow exposure to humans, to potentially or susceptible infected animals or their products (Carrera *et al.*, 2006).

RESULTS AND DISCUSSION

To have an insight in to the role of cattle in the epidemiology of brucellosis, we conducted a study to determine the prevalence of brucellosis in some settled cattle Farms in Daura Local Government Area, Katsina State, Nigeria. A total of 500 Bovine serum samples were collected from six settled Cattle farms and tested for the presence of *Brucella* antibodies using Rose Bengal Plate Test (RBPT) as described by Alton *et al.* (1975).

The overall prevalence of brucellosis observed in all the six farms combined was 35 (7%). This is in line with the result of the investigation carried out on cattle by Adamu *et al*. (2016) in three senatorial zones of Katsina State which revealed the prevalence of (5.4%) using RBPT. Similarly, Farouk *et al*. (2011) also reported the much lower overall herds' prevalence of (4.04%) using RBPT from Jigawa State.

The prevalence among the age groups showed that cattle aged between 3-6 years had a prevalence of 18 (3.6%) followed by those between the ages of 7-9 years 11 (2.2%), 0-3 years 5 (1%), and those aged above 9 years 1 (0.2%). This supported the result of investigation conducted in Katsina State by Adamu *et al*. (2016), which reported the seroprevalence of 6.3% in cattle aged 4-5 years, followed by 5.5% in cattle aged <4 years then cattle with the age band of 5-7 years shows the prevalence of 4.6%, whereas cattle aged above 7 years shows the least seroprevalence of 4.0%. Our result revealed no statistically significant association at ($p \leq 0.05$) among all the age groups tested. This is also as reported by Adamu *et al*. (2016).

Based on sex, the result revealed the highest prevalence in female than in male with 22 (4.4%) and 13 (2.6%) respectively using RBPT. Statistically, this shows the significant association between the sex of cattle and the prevalence of the disease at (≤ 0.05). This is because female cows remain the locale of infection, which helps to spread the disease from one animal to another, either through lactation or during mating. Pregnancy and lactation were reported to enhance susceptibility to infection. The growth of virulent strains of *Brucella* organism was reported to be stimulated more in females because of the presence of higher volume of D-erythritol normally found in fetal tissue than in testes and seminal vesicle (Bayemi *et al*., 2009). These thoughts provide proofs as to the different rates of prevalence of bovine brucellosis in relation to sex of animals concern. In addition, this finding agreed with earlier reports of Junaidu *et al*. (2011) which stated that the foci of *brucella* infection remain in females, which spread the infection from one animal to another. Also, Adamu *et al*. (2016) reported the similar result of higher prevalence in female (7.6%) than male (5.8%).

In regard to the breeds of cattle examined, the highest rate of infection was indicated in white Fulani (Bunaji) with prevalence of 18 (3.6%) followed by Friesian with 8 (1.6%), Cross breeds 5(1%), Wadara 3(0.6%), Bokolo 1 (0.2%) and Bororo 0 (0%). There was no significant association between the breeds of cattle examined and the prevalence of the brucellosis at ($p \leq 0.05$). This corresponds with the report of Saleh *et al*. (2017) who reported that brucellosis is more prevalent in white Fulani among cattle slaughtered in three municipal abattoirs of Jigawa state. Cadmus *et al*. (2006) also reported the highest prevalence of Brucellosis in White Fulani cattle over Red Bororo, Sokoto gudali and Cross breeds.

CONCLUSION AND RECOMMENDATIONS

This study shows that brucellosis is endemic in the study area. Cattle of all ages and both sexes were carrying the disease and infected cattle in the herds examined were likely to transmit the disease to humans and other susceptible animals. It is recommended that thorough antimortem and post-mortem inspections should be carried out daily and slaughtered and all infected animals should be isolated and treated immediately slaughtered to enable the total eradication of the disease. Food products derived from animals should be properly cooked to protect the consumers from *Brucella* infection and integrating vaccination against brucellosis into the annual vaccination program of livestock is highly recommended.

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EFFECTS OF STORAGE METHODS AND DURATION ON SOME QUALITY PARAMETERS OF JAPANESE QUAIL EGGS

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ABSTRACT
The study determined the effects of storage methods and durations on some quality parameters of Japanese quail eggs. The study was conducted at the laboratory of the Federal Polytechnic Daura, Daura, Katsina state, Nigeria. A total of 100 freshly laid eggs of Japanese quails were used for the experiment, the eggs were obtained from the poultry farm of Federal Polytechnic Daura, Daura, Katsina state. The experiment was laid in a 4 by 4 factorial arrangement in a completely randomized design (C.R.D) consisting of 4 storage methods namely oiling or shell coating, Room temperature, Earthen pot and covering with leaves and 4 durations of storage i.e. 0, 7, 14, and 21 days and 4 replicates respectively. All the proximate values for all the storage methods and durations were all significantly (p<0.05) different, values for moisture under oiling method ranged from 2.00 – 3.00%. Values for crude protein under storage duration ranged from 27.20 - 35.00%. Values for Haugh unit for clay storage varied from 56.00 – 58. 20%, while yolk index for oiling method ranged from 0.20 to 0.40. It was concluded that oiling method best preserved the egg of the four methods used. Oiling storage method was recommended for storing and preserving Japanese quail eggs
Keywords: *Storage, Duration, Quality Parameters, Japanese Quail, Eggs*

INTRODUCTION
The market for Japanese quails *(Coturnix japonica*) has long provided developing countries with a stable vitamin-rich source of alternative animal proteins that are low in fat content, plus eggs that contain 2.47 percent less fat than chicken eggs, all working together to boost the human immune system. High level of phosphorus, iron, and vitamin A, B1, and B2 all mean that quail fit nicely into society's definition of what constitutes a healthy diet and lifestyle. Bruce (2019).
All foods have limited shelf life which vary on the type of food, place of the storage and storage condition. Eggs deteriorates rapidly between the period of storage and consumption. Egg quality can be affected by the environmental condition as well as it nutritional properties and values such as temperature, relative humidity of storage as well as gaseous environment storage time. Storage can modify some characteristics of eggs including loss of water, carbon dioxide, and subsequent increase in pH of the albumen Ducupere, (2001). Quality parameters are factors or limits which affect the way eggs can be stored. Any given food has an influence on the acceptance and rejection of the food by the consumers, this is as a result of either internal or external quality problems. External quality parameters of egg is focused on shell cleanliness, texture, and shape whereas, internal quality parameters refers to egg white (albumen) cleanliness and viscosity, size of the air cell, Yolk shape and yolk strength (Kul and Seker, 2004). The objective of this study therefore was to determine the effects of some storage methods and duration on some quality parameters of Japanese quails' eggs, with a view to advising farmers, Quail egg sellers and consumers appropriately.

MATERIALS AND METHODS
Experimental Location
The study was conducted at the laboratory of the Federal Polytechnic Daura, Daura, Katsina state. Daura is a local government in Katsina state and it lies on Latitude 13^0 1'53.38"N, and Longitude 8.19'21.12"E. Daura has an area of 217.3KM^2 and population of around 224,884 persons. The area has two distinct climate, rainy season approximately from May to October and dry season from November to April with an average annual rainfall of 190mm (7.48) (National Geospatial Intelligence Agency, 2012).

Experimental Eggs

A total of 100 freshly laid eggs of Japanese quails were used for the experiment, the eggs were obtained from the poultry farm of Federal Polytechnic Daura, Daura, Katsina state.

Experimental Design

The experiment was laid in a 4 by 4 factorial arrangement in a completely randomized design consisting of 4 storage methods namely Oiling or Shell coating, Room temperature, Earthen pot and covered with leaves and 4 durations of storage i.e. 0, 7, 14, and 21 days and 4 replicates with 25 eggs per replicate

Experimental Procedure

A total of 100 freshly laid eggs of almost equal size from *Coturnix japonica* breed of layers in poultry farm of Federal Polytechnic Daura were obtained and divided into 4 equal parts comprising 25 eggs were stored in each 4 different storage methods as shown beneath.

Oiling: (shell coating) In this method the eggs was immersed into odourless ground nut oil, allowed to drain for at least 1 minute and stored at room temperature on a flat surface.

Could it be that a plate supposed to be here? If yes insert it

If no, delete this caption Eggs coated with groundnut oil and stored under room temperature Room temperature (Untreated): In this method the eggs was placed in egg tray untreated and store at room temperature.

Plate 1: Eggs coated with groundnut oil and stored under room temperature

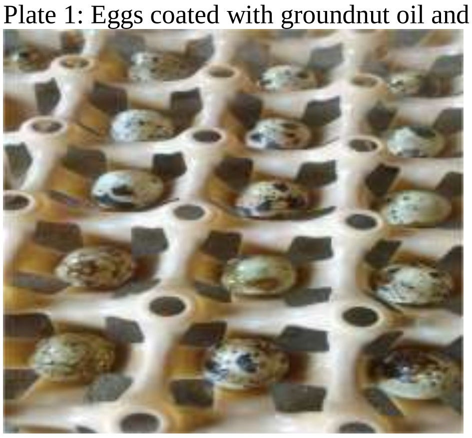

Plate 2: Eggs stored under room temperature (Untreated)

Earthen pot: In this method the eggs was kept in a wide-mouthed earthen pot and stored at room temperature.

Plate 3: Eggs stored in earthen pot under room temperature

Covered with leaves=In this method the eggs were kept at room temperature and covered them with fresh mango leaves. The leaves were changed every 48 hours.

Plate 4: Eggs stored under room temperature and covered with mango leaves

Determination of Quality Parameters of Eggs

The quality parameters were determined using AOAC (2012). Moisture content was determined by drying in hot air oven at 100-102^{0}C for 16-18 hours. Crude protein was estimated by multiplying 6.25 by the nitrogen content obtained through Kjeldal method. Ether extract and ash were analysed by Soxhlet extraction and 550^{0}C furnace respectively.

Data Analysis

The data collected were subjected to analysis of variance and significantly different means were separated using least significant difference with the aid of statistical package (SPSS, 2015).

RESULTS AND DISCUSSION

Effects of Different Storage Methods on the Proximate Composition of Quail Eggs

The effects of different storage methods on the proximate composition of Japanese quail eggs is presented in Table 1. All the values for the different storage methods were significantly different ($p<0.05$), the values did not follow any definite trend, values for moisture ranged from 2.00 to 3.00%. This result was similar to that reported by Dudusola (2009) in Japanese quail eggs.

The parameters for determining quality of eggs are at maximum when the eggs are freshly laid and decrease with increase in storage time (Panigraphi *et al.*, 1989) . Storage conditions are chosen with regard to the retention of these quality characteristics. Temperature, relative humidity and air flow or moisture are considered as the main factors in determining the technological conditions for egg storage (Orji *et al*., 1981). The low weight loss of oiled eggs may be due to blockage of the shell pores by thin film of oil thus preventing water and gaseous escape (Dudusola, 2009).

Table 1: Effects of Different Storage Methods on the Proximate Composition of Quail Eggs

Storage Method	Proximate Values (%)			
	Moisture	Ash	Crude Protein	Ether Extracts
Oiling	3.20^{a}	32.80^{a}	29.80^{a}	13.30^{a}
Room temperature	2.00^{b}	28.60^{b}	20.80^{a}	10.40^{b}
Clay pot	2.90^{a}	32.30^{a}	28.40^{a}	12.80^{a}
Covered with leaves	2.30^{b}	32.50^{a}	22.00^{b}	11.50^{b}
SEM	0.65	1.51	1.61	1.02

a,b, Treatment Means with Different Superscripts along the columns are Significantly ($P <0.05$) Different, SEM Standard Error of Means

Effect of Storage Duration on Proximate Composition of Quail Eggs

The effects of storage duration on the proximate composition of Japanese quail eggs is presented in Table 2
The proximate values for all the storage durations showed significant difference ($P<0.05$). The values for crude protein ranged from 27.00 - 35.00%. The values showed that the longer the storage duration the more the deterioration of the eggs. This was in agreement with the report of Dudusola, (2009) with Japanese (Quail eggs). With increase in storage length egg weights decreased as a result of increase in weight losses. The losses may be due to loss of carbon dioxide, ammonia, nitrogen, hydrogen sulphide, gas and water from the eggs (Haugh, 1993).

Table 2: Effect of Storage Duration on Proximate Composition of Quail Eggs

Storage Duration (Days)	Proximate Values (%)			
	Moisture	Ash	Crude Protein	Ether Extracts
0	15.50^{a}	3.40^{a}	35.00^{a}	32.00^{a}
7	12.90^{b}	2.70^{b}	30.50^{b}	25.30^{b}
14	5.00^{c}	2.00^{c}	28.30^{c}	22.10^{c}
21	4.60^{d}	1.80^{d}	27.20^{c}	20.20^{d}
SEM	1.21	0.75	1.05	1.01

a,b,c,d Treatment Means with Different Superscripts along the columns are Significantly ($P <0.05$) Different; SEM Standard Error of Means

Effects of Different Storage Methods and Storage Duration on Quality Parameters of Quail Eggs

Effects of Different Storage Methods and Storage Duration on Quality Parameters of Japanese Quail Eggs is presented in Table 3. All the values for the quality parameters viz-a-viz the storage methods and storage duration were significantly different ($p<0.05$) except the Haugh unit in oiling, clay pot and covering leaves treatments. The values generally showed lower quality parameters with longer storage days. Haugh unit values for clay pot storage ranged from 56.00 to 58.20%, while yolk index values for oiling method ranged from 0.20 – 0.40. Oiling method provided the best preservation method of all the 4 methods determined. Dudusola (2009) reported that refrigeration and oiling were the best eggs storage methods.
Haugh unit and yolk indices are generally considered as good indicators to evaluate egg quality (Chang *et al*., 2000)). The higher the yolk index (Ayorinde, 1987)) and the Haugh unit (Haugh, 1993) the more desirable the egg quality. The variations observed in eggs stored under different methods and different storage durations indicates chemical degradation and favourable environment for bacterial activity. Haugh units are 75% and above for excellent quality eggs and 50% and below for stale eggs. The Haugh unit of 56.60 – 58-30 % were far below 75% and above for excellent eggs. These values were also lower than 58.60 - 62.10% reported by Dudusola (2009).

Table 3: Effect of Different Storage Methods and Storage Duration on Quality Parameters of Japanese Quail Eggs

Quality Parameters/ Storage Methods	Storage duration 0	7	14	21	SEM
YOLK INDEX					
Oiling	0.40^a	0.30^b	0.20^c	0.20^c	0.04
Untreated	0.40^a	0.20^b	0.10^c	0.10^c	0.20
Clay pot	0.40^a	0.30^b	0.10^c	0.10^c	0.03
Cover with leaves	0.04^a	0.30^b	0.20^c	0.20^c	0.04
HAUGH UNIT (%)		`			
Oiling	56.60	58.30	55.70	55.70	2.10
Untreated	57.40^a	54.50^b	54.00^b	52.60^b	2.75
Clay pot	58.20	57.70	56.00	53.80	3.10
Covered with leaves	58.60	58.10	57.20	54.80	2.80
EGG WEIGHT(g)					
Oiling	11.40	11.10	11.40	11.20	0.09
Untreated	11.70^b	13.00^a	12.40^a	12.10^a	0.03
Clay pot	11.40^b	11.20^b	12.00^a	12.10^a	0.04
Covered with leaves	11.40^c	11.20^c	12.00^b	13.10^a	0.02
EGG WEIGHT LOSS(g)					
Oiling	0.00^d	0.10^c	0.20^b	0.40^a	0.04
Untreated	0.00^d	2.80^c	3.80^b	5.40^a	0.06
Clay pot	0.00^d	0.30^c	1.30^b	2.60^a	0.06
Covered with leaves	0.00^d	0.70^c	1.80^b	3.10^a	0.05

a,b,c,d Treatment means with Different Superscripts across the rows are Significantly ($P<0.05$) Different; SEM Standard Error of Means

CONCLUSION AND RECOMMENDATIONS.

Conclusion

This study showed that oiling was seemingly the best method to preserve Japanese quail eggs.
The shelf life of Japanese quail eggs is short, just like other eggs, no matter the storage method deterioration will set in,

RECOMMENDATIONS

Japanese quail eggs may not be stored for more than 21 days but oiling method may be recommended for storage and preservation of Japanese quail eggs

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CHEMICAL AND MINERAL COMPOSITIONS OF MISTLETOE GROWING ON *ADONSONIA DIGITATA* (*TAPINANTHUS GLOBIFERUS*) FROM SEMI-ARID BROWSES IN JIGAWA STATE, NIGERIA.

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ABSTRACT

The study was conducted to evaluate mistletoe as a feed resource for ruminant animals in Jigawa State. Proximate and mineral composition of the plant suggested its potentials to meet some of the nutritional requirements for utilization as livestock feed. Sixteen (16) samples were allotted into (4) treatment and (4) four replication in a Completely Randomized Designed (CRD) dry matter (DM),17.39% crude protein (CP), 25.85% crude fibre (CF), 3.65% this indicate higher protein % moderate dry matter and low crude fibre. While macro mineral was significantly (P>0.05) higher in phosphorus (P) 226.52ppm with low in potassium (K) 3.12 ppm. Micro mineral was significantly (P>0.05) higher iron (Fe) 9.72ppm and low in manganese (Mn) 0.04ppm. Therefore, mistletoe of Adonosonia digitata (Tapinanthus globiferus) contained some adequate nutrients and alternative minerals for ruminant feeding especially in dry season.

Keywords: *Ruminant animals, mistletoe, Adonosonia digitata (Tapinanthus globiferus), livestock feed.*

INTRODUCTION

Nutrition is the single most important factor militating against livestock production in Nigeria (Bishir *et al.*, 2021). Thus, there is need to search for alternative feedstuffs that are locally available and cheap. Feed tends to be the most considered amongst factors influencing livestock production (Tunde and Agustine, 2016; Devendra and Leng, 2011). At critical dry season, available feed for grazing by animals are almost bare ground with poor vegetation cover and low biomass (Muhammad and Kallah, 2013). The main problem confronting ruminant livestock producers in Nigeria today is the seasonal fluctuation in the availability of forages for ruminants (Bukola *et al.*, 2022). Browse plants comprised of annual or perennial trees, shrubs and woody vines that are either legumes or non-legumes. They have a great value in the extensive system of animal production in the arid and semi-arid region (Amodu and Otaru, 2004). The use of protein-rich leguminous trees and shrubs appears to be one sustainable solution for dry season ruminant supplementation in the tropics (Saleh *et al.*, 2015). The use of leaves from trees that retain their leaves during the long dry season, to feed ruminants during the difficult period is very important (Bukola *et al.*, 2022). Mistletoe is a general term for woody shoot parasites in several plant families, especially in *Loranthaceae* and *Viscaceae* families (Ogunmefun *et al.*, 2013; Begho *et al.*, 2007). It is popularly called "*Kauchi*" and "*ewe afomon*" among the Hausa/Fulani and Yoruba speaking people of Nigeria, respectively (Saleh *et al.*, 2015). It is an obligate semi-parasitic evergreen tropical plant, normally found growing on a variety of trees, including palm fruit, mahogany and other tropical plants (Saleh *et al.*, 2015). Mistletoes as part of an ecosystem, attracts avian frugivores and exotic animals (Garnett *et al*., 2016; De Buen and Ornelas, 2001). According to Godschalk (1983), mistletoe provide birds for nourishment (protein 6%; lipids 44% and sugars 12%)

as well as hiding and nesting sites for birds and other reptiles (Parks *et al.*, 1999). Therefore, the study aimed to evaluate the proximate and mineral composition of mistletoe (*Viscum album*).

MATERIALS

Mistletoe plant
Milling machine

METHODS

Research Design

A completely randomized design (CRD) was used, as outlined by Steel and Torrie (1980). The mistletoe plant meal (MTPM) was used as four samples representing four (4) different local government areas (Miga, Garki, Kaugama and Maigatari local governments, respectively). The samples were randomly allotted to four (4) treatment groups with four (4) replicates.

Data obtained from the experiment were subjected to analysis of variance (ANOVA) procedure of Statistical Analysis System (SAS, 2003). Software package version (16) were significant differences observed between the treatments, the means were separated using Duncan multiple range test at 5% level of probability (Duncan, 1995).

Sample Preparation and Treatment

Jigawa State is located in the semi-arid region of Nigeria and lies between coordinates 12.2280°N; 9.5616°E. The annual rainfall distribution ranges from 42.97mm (1.69 inches) of precipitation and has about 60.55% rainy days (16.59% of the time) annually. https://tcktcktck.org. Rainfall normally last for an average of five (5) months, while, the rest of the year is dominated by dry season. The mean annual temperature in the area can be as high as 38.94^{0}C and could be as low as 24.93^{0}C. https://tcktcktck.org. The soil type of the area is sandy loam, with little organic matter. The natural vegetation of the area is Sudan savannah type, which consisted of moderately tall grasses such as *Andropogon gayanus, Panicum maximum, Pennicetum pedicellatum* etc, and scattered browse species like *Acacia spp*, *Balanite agiptica, Zizipus* spp, *and Pilliostigma thoningii.* The area supports good Agricultural activities with Sorghum, millet, cowpea, groundnut and sesame being the major crops cultivated (Danladi *et al*., 2015).

Mistletoe of *Adonsonia digitata* (*Tapinanthus globiferus*) was randomly obtained as four samples from four different local government areas of Jigawa State, and air-dried under the shed daily for about seven (7) days until they became crispy, while retaining the greenish coloration. The air-dried samples were milled into coarse texture, using machine to produce mistletoe plant meal (MTPM). For proximate and mineral analysis.

RESULTS AND DISCUSSION

The mistletoe of the MPTS (*Adonsonia digitata*) had less anti-nutritional factors and was more abundant in the study area. Therefore, it was selected for proximate analysis. The results of chemical composition of mistletoe of *Adonsonia digitata (Tapinanthus globiferus)* were presented in Table 4.7. Mistletoe of *Adonsonia digitata* contains 87.88% dry matter (DM),17.39% crude protein (CP), 25.85% crude fibre (CF), 3.65% ether extract (EE),10.35%, ash, 42.76% nitrogen free extract (NFE), 31.70% neutral detergent fibre (NDF), 18.45% acid detergent fibre (ADF), 5.23% acid detergent lignin (ADL), 13.22% cellulose and 13.25% hemicellulose.

Table 1. Chemical composition (%) of the Mistletoe of *Adonsonia digitata (Tapinanthu globiferus*)

Parameters	Values
Dry matter	87.88
Crude protein	17.39
Crude fibre	25.85
Ether extracts	3.65
Ash	10.35
Nitrogen free extracts	42.76
Neutral detergent fibre	31.70
Acid detergent fibre	18.45
Acid detergent lignin	5.23
Cellulose	13.22
Hemicellulose	13.25

The results of mineral analysis of mistletoe of *Adonsonia digitata (Tapinanthus globiferus)* were presented in Table 1. The results showed that, the mistletoe had mean, calcium content of 13.83ppm, magnesium 18.10ppm, potassium 3.12ppm, sodium 24.87ppm and phosphorus 226.52ppm. Similarly, the mistletoe had 0.32ppm zinc, 0.04ppm manganese, 0.29ppm copper, and 9.72ppm iron.

Table 2. Mineral Composition (ppm) of mistletoe of *Adonsonia digitata (Tapinanthus globiferus)*

Parameters	Values
Macro minerals	
Calcium (Ca)	13.83
Magnesium (Mg)	18.10
Potassium (K)	3.12
Sodium (Na)	24.87
Phosphorus (P)	226.52
Micro minerals	
Zinc (Zn)	0.32
Manganese (Mn)	0.04
Copper (Cu)	0.29
Iron (Fe)	9.72

From Table 2 above, the factors causing variation in the chemical composition of browses and forages include soil types, climate, plant part (leaf, stem and fruit), age and season. The dry matter (DM) values of mistletoe of *Adonsonia digitata (Tapinanthus globiferus*) obtained in this study were similar to 92.30% reported by Anthony *et al*. (2017), for mistletoe (*Viscum album)* leaf meal as feed additive for broilers. This implied that, mistletoe species are high in dry matter. And hence high energy value. The crude protein (CP) value of mistletoe obtained in this study was higher than the value (12.50%) reported by Franklin *et al*. (2017), when mistletoe of *Phragmanthera capitate,* (a mistletoe growing on rubber trees) was evaluated for proximate composition. However, the slight differences might have occurred as a result of studying other parts of the plant as test materials, not leaves alone. Crude fibre (CF) values obtained in this study were lower than CF value (28.19%) reported by Saleh *et al.* (2015), for Mistletoe of *Parkia biglobosa*. The value of ether extract (EE) in the present study were lower to those (4.13%) reported by Saleh *et al*. (2015), for Mistletoe of *Parkia biglobosa*. Nitrogen free extract (NFE) values in this study were similar to the values reported by the same author for mistletoe of *Feildherbia albida*. The ash content of the test plant was higher than 5.16% reported by Saleh *et al*. (2015) for the chemical composition of mistletoe of *Vitallaria paradoxa*. The similarities could be as a result of using plants of the same Genus – *Tapinanthus*.

Fibre is the predominant fraction of the plant cell wall and primarily comprised of carbohydrates. The primary components of fibre are cellulose, hemicellulose and lignin. However, the neutral detergent fibre (NDF) value obtained in this study was lower than the value 48.50% reported by Kubkomawa *et al*. (2017) of mistletoe *Balanite aegyptica*. Acid detergent fibre (ADF), acid detergent lignin (ADL) values obtained in this study, were similar to reported values of (19.60%) and (5.61%), respectively (Kubkomawa *et al*., 2017). Cellulose and hemicellulose values reported in this research were similar to those values 12.47% and 12.50%, respectively, recorded by Kubkomawa *et al*. (2017). This considering the chemical composition of mistletoe, it implies that it could be a good feed ingredient for ruminant animals.

Mistletoe plant is an excellent source of alternative minerals for ruminant animals Madibela *et al*. (2000). The mineral values of mistletoe of *Adonsonia digitata (Tapinanthus globiferus)* obtained in this study were lower than the values 622.58. Ca, 361.15. Mg, 1047.83. K, 115.40. P, 19.23. Na, 2.49. Zn, 1.81. Cu, 27.57. Mn, and 105.15. Fe, (Mg/100g) reported by Franklin *et al*. (2017). The values were obtained for mineral analysis of *Phragmanthera capitate,* a mistletoe growing on rubber trees. However, the variation could be as a result of differences in tree plants, test materials, time of sampling and climatic condition of the environment on which they grow. Franklin *et al*. (2017) reported that, the body of animals need macro minerals in moderate proportion and micro in very small amounts. According to Duyff (2002), some minerals are structural components (calcium and phosphorus) while others are haemostats (sodium and magnesium) and yet others are component of organic bimolecular (all trace elements such as zinc, iron). Mgbemena and Obodo (2016), reported higher values of Ca, Mg, K, Na, and P as 2.61- 4.22, 1.094 -1.64, 0.625 - 0.850, 0.300 - 0.825 and 0.249 – 0.758 %, respectively, for *Moringa oleifera* roots, leaves and seeds. However, all the values obtained for the mineral contents showed that, mistletoe could be a very good source of minerals for ruminants feeding. Minerals are essential elements in animal nutrition as they fulfil multiple functions in the physiology of all systems (Jerson, 2021). Macro minerals are the group of mineral elements most needed by animals in their diet to fulfill a numerous of physiological functions, deficiencies of these elements cause various pathologies or dysfunctions that must be promptly corrected. Moreover, depending on the animal species (poultry, swine, or ruminant), the signs and effects may vary (Jerson, 2021). Micro minerals are elements that are found in smaller quantities compared to macro minerals. However, they also fulfill many functions in the physiology of animals. The functions of micro minerals are the same for animals as they constitute basic processes for animal life (Jerson, 2021).

CONCLUSION AND RECOMMENDATION

Mistletoe of *Adonosonia digitata (Tapinanthus globiferus)* contained some adequate nutrients and alternative minerals for ruminant feeding especially in dry season. Used of mistletoe as animal feed resources could improve growth performance, nutrient intake and digestibility of animal especially in the dry season.

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ZIZIPHUS MAURITIANA AND ITS UTILIZATION AS A LIVESTOCK FODDER: A REVIEW

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ABSTRACT
Ziziphus species are drought-tolerant plants found in warm-temperate, tropical, and subtropical regions of the world. They include a variety of plants, from shrubs, small to medium-sized trees, and they have a wide range of canopy morphology, including spreading, semi-upright, and erect. However, they are highly significant for their nutritional value and their numerous roles in dry zone agroforestry systems, including soil cover, wind protection. Ziziphus mauritiana grows naturally, it is widely recognized as a cultivated fruit tree that has sub-spontaneously spread in several tropical and sub-tropical regions of the world. It is a great top feed species that produces nutrient-rich leaves that are used as source of fodder for desert animals like sheep, goats, camels, and cattle. ***Ziziphus fruit has a pleasant aroma and chemically, it is a nutrient powerhouse, containing high levels of protein, fiber, and vitamin A, B, C, flavonoids, tannins, lipids, alkaloids, steroids, carbohydrates, calcium, potassium, sodium, phosphorus, copper, iron, and zinc.*** *Z. mauritiana inclusion at 8 to 10% (DM) dry matter was reported to boost feed intake, milk yield, milk quality in nursing cows while also improving feed nutrient utilization., this also allow dairy cows to maintain a normal rumen environment and enhanced the feed's flavor, nutrient digestibility, and lactation efficiency. Z. mauritiana is palatable and is high in energy, protein as well as minerals contents, rich in vitamins and has antidiarrheal, antibacterial, immune promoting, and antioxidant properties. Optimal feeding level recommendations and processing technology should be improved. In addition, attention should be paid to the feeding safety of microbial populations, mycotoxins and heavy metals in Z. mauritiana by-products.*

INTRODUCTION
Researchers and developers are paying greater attention to the use of functional feed additives as a result of the strict regulations for the use of antibiotics in animal feed as well as the rising standards for the quality and safety of foods derived from animals (Xu *et al*., 2022). *Ziziphus* species are found in South Asia, Africa, and the warm subtropics and tropics regions of the world. The pulp from the fruits, which is consumed fresh or dry and can also be turned into a juice, is the major product of these species. Additionally, leaves are utilized as fodder and for medicine. Bark, roots, and leaves are also used as feed, whereas, the wood is utilized for handles, cooking utensils, firewood, and charcoal (Kalinganire and Koné, 2011). *Ziziphus* species are drought-tolerant Rhamanaceae plants found in warm-temperate, tropical, and subtropical regions of the world. They include a variety of plants, from shrubs, small to medium-sized trees, and they have a wide range of canopy morphology, including spreading, semi-upright, and erect. *Ziziphus species* are significant not only for their nutritional value but also for their numerous roles in dry zone agroforestry systems, including soil cover, wind protection (Macwan *et al*., 2012; Riaz *et al*., 2021; Singh and Meghwal, 2020). It is commonly called Indian jujube, Indian plum, Chinese date, Chinee apple, ber and dunks (Morton, 1987).

Ziziphus mauritiana trees are used as food, fodder, and medicine; they produce effectively and tolerate in high temperatures and short rainfall. However, cultivation of these trees could be a solution to the problem of food insecurity and a source of income for households in arid and semi-arid areas as a result of the current impact of climate change (Muhammad *et al*., 2022). Fruits like *Ziziphus mauritiana* are high in energy and have anti-inflammatory, antibacterial, and anti-diarrheal effects (Maaiden *et al*., 2020; Xu *et al.*, 2022). *Z. mauritiana* by-products are widely produced due to the growing territories under *Z. mauritiana* tree cultivation and the heavy processing of jujube throughout Arid and Semi-arid areas of the world. These byproducts are frequently used into animal feed for pigs, fowl, cattle, goats, and fish because they support healthy digestion, increase growth performance, and improve the quality of animal products (Singh and Meghwal, 2020; Xu *et al*., 2022). *Z. mauritiana* is a plant that grows naturally or is widely recognized as a cultivated fruit tree that has sub-spontaneously spread in several tropical and sub-tropical regions of the world *(*Macwan *et al., 2012;* Riaz *et al.*, 2021; Uddin *et al*., 2019; Yahia *et al*., 2020). It is a small, spiny tree or shrub that can grow to a height of 10 m. It has a trunk that is at least 30 cm in diameter, a spreading crown, numerous spines, and a number of drooping branches. The bark is markedly dark gray or dull black with irregular fissures (Uddin *et al*., 2019). It is a great top feed species that produces nutrient-rich leaves that are used as a wonderful source of fodder for desert animals like sheep, goats, camels, and cattle (Singh and Meghwal, 2020).

Cattle, sheep, pigs, goats, and other farm animals are considered livestock. They serve a variety of purposes, including providing food (meat and milk) and other benefits like security, drought power, manure production (dung and urine), biofuel production, social values, and recreation. However, some of these animals, like ruminants (cattle, sheep, and goats), are herbivorous in nature, which means that the majority of their nourishment comes from grazing on natural pasture, fallow ground, and cropland (Lamidi and Ologbose, 2014).

BOTANICAL DESCRIPTION OF *Ziziphus mauritiana*

Ziziphus mauritiana is a tiny, heavily branched tree or frequently a large bushy shrub with short stipular spines, a corky stem, a powerful root structure, and the ability to be evergreen or go leafless for a brief period of time during hot summers (Singh and Meghwal, 2020; Tripathi and Preeti, 2014). It can grow in a variety of ways, from an upright branching habit to a drooping and spreading type. The leaf apex was sharp or obtuse, and the leaves were elliptical, elliptic to ovate, or oblong. The ventral surfaces of the leaves were smooth to rough to mentose with reticulate venations, whilst the dorsal surface was smooth (Tripathi and Preeti, 2014; Yassine *et al.*, 2020). In August and September of the current growing season, tiny, greenish-yellow flowers on a short stalk bloom in the axils of the leaves. The fruits are drupes that range in size and form from round to rectangular, oval, and obovate. As the fruit ripens, the smooth skin turns from light green to yellow. A single, tough, rough, oval or oblate center stone houses two elliptical, brown seeds (Singh and Meghwal, 2020).

***Ziziphus mauritiana* PLANT PARTS**




Figure 1: Leaves **Figure 2: Flower** **Figure 3: Fruits** **Figure 4: Seeds**

SCIENTIFIC CLASSIFICATION OF *Ziziphus mauritiana*

Kingdom	Plantae
Division	Magnoliophyta
Subdivision	Angiosprm
Class	Magnoliopsida
Order	Rosales
Family	Rhamnaceae
Genus	*Ziziphus*
Species	*Mauritiana*

Sources: (Macwan *et al*., 2012; Parmar *et al*., 2012; Tripathi and Preeti, 2014)**.**

Chemical Composition of *Ziziphus mauritiana* Fodder Fractions

As a browse plant, *Z. mauritiana* meets the majority of the nutritional needs of goats and camels while also supplementing the diets of cattle and sheep with the protein, vitamins, and minerals that bush straw lacks during the dry season (Yahaya *et al*., 2021). Yerima and Adamu (2011) reported the highest crude protein (36.10%) in *Z. mauritiana* seeds, while Keta (2017) reported the lowest crude protein (6.18%) in *Z.mauritiana* fruits pulp. This was higher than the suggested %CP requirement for maintaining sheep and goats, which was reported by NRC (2007) as 9.4 and 7.93%CP, respectively.

According to Abdurrahaman *et al*. (2021), the high levels of fiber content were among the reasons that led to the low concentration of protein. For the moisture (5.16%; 4.21%) and ash (6.16%; 2.79%) levels in the pulp and seeds of *Z. mauritiana* fruits, respectively, Keta (2017); Yerima and Adamu (2011) found lower values. *Ziziphus mauritiana* leaves had the highest neutral detergent fiber content (NDF) of 575.40 g/kg and the highest acid detergent fiber content (ADF) of 228.30 g/kg (Njidda and Olatunji,2012).

***Ziziphus* fruit has a pleasant aroma and it includes high levels of protein, fiber, and vitamin A, B, C, flavonoids, tannins, lipids, alkaloids, steroids, carbohydrates, calcium, potassium, sodium, phosphorus, copper, iron, and zinc** (Maaiden *et al*.**,** 2020; Rabie *et al.*, 2019; Riaz *et al*.**,** 2021**;** Tripathi and Preeti**,** 2014**).** ***Ziziphus* species extracts and fractions of the leaves, fruits, and seeds have demonstrated antiviral, antifungal, and antibacterial activity and have been used in medicine to treat a variety of illnesses, including diarrhea and conditions of the digestive tract. (Maaiden *et al*., 2020; Rabie *et al*., (2019).** Analysis of the chemicals constituents on a dry weight basis indicates that the leaves contain 15.4% crude protein, 15.8% crude fibre, 6.7% total minerals, and 16.8% starch (Orwa et al., 2009). **Ground seeds on extraction with petroleum ether gave 33% of bright yellowish oil. Fatty acid composition of the oil contains oleic acid- 71.7%, Linoleic acid- 15%, while the fruits are very rich in vitamins C and B1 and B2 (Tripathi and Preeti, 2014).**

Uses of *Ziziphus mauritiana* in Livestock Feed

Cattle, camels, goats, and other animals eat the leaves of the *Ziziphus mauritiana* plant, which provides them with nutrients good for their health such as carbohydrate, proteins, minerals, and vitamins (Parmar *et al*., 2012). *Z. mauritiana* is a desirable ingredient for animal feed due to its abundance, affordability, and health benefits. It is currently available as dried powder, pellets, fermented powder, and complete feed. However, these products have been studied for use in animal feed on a global scale. Many studies on the impact of *Z. mauritiana* on ruminant milk production have been published. Industrial by-product of *Z. mauritiana* was added to diets to boost feed intake, milk output, and milk quality in nursing cows as well as improving feed nutrient utilization. The ideal amount of *Z. mauritiana* residue to add to a meal was 8 to 10% dry matter; this allowed dairy cows to maintain a normal rumen environment and enhanced the feed's aroma, nutrient digestibility, and dairy productivity (Xu *et al*., 2022). Badakaya *et al.* (2021) and Abdu *et al*. (2012) reported higher weight gain in growing Rabbits fed diet containing 45% and 10% *Z. mauritiana* leaves respectively. In broilers and laying hens, the effects of supplementing the diet with *Z. mauritiana* leaves powder have been studied. *Z. mauritiana* powder replaced 10 - 15% of the maize in the feed of Taihang hens, which reduced stress, boosted protein synthesis, raised serum globulin levels, encouraged the growth and development of immunological organs, increased pathogen resistance, and increased survival rates (Xu *et al*., 2022). Khan *et al*. (2009) reported the results of an experiment with Beetle goats supplemented with *Z. mauritiana* leaves, which resulted in a final body weight gain of (56 kg). The average body weight gain, organic matter, crude protein, and acid detergent fiber were all enhanced by replacing maize with 5 to 20% *Z. mauritiana* powder, which also raised the net meat output and dressing percentage in Jinlan Cashmere goats (Xu *et al*., 2022). The *Longissimus dorsi* muscle's pH and crude fat content fell when *Z. mauritiana* powder was added to the meal, while the meat's protein and amino acid content, as well as the amounts of Ca, K, Mg, Na, Mn, Fe, and Zn, increased the composition of fatty acids was unaffected. Therefore, 15% jujube was suggested as the best amount for goats since it improved meat quality and increased growth performance (Xu *et al.*, 2022). In a study on fattening lambs, Xu. (2022) reported that jujube consumption decreased blood concentrations of urea nitrogen, total cholesterol, and triglycerides without changing blood glucose or insulin levels.

Other Uses of *Ziziphus mauritiana* Fodder Fractions

Various plant components can be used medicinally to cure a range of local health issues (Maaiden *et al*., 2020; Singh and Meghwal, 2020); the roots are used as a decoction to treat fever and the powder from the roots is applied to ulcers and old wounds, the bark is used to treat diarrhea, the leaves are used to treat wounds as poultices and are beneficial for liver problems, asthma, stomatitis, gum bleeding, and fever, the fruits have laxative, energizing, burning-sensation-removal, thirst-relieving, vomiting-control, and blood-disorder-controlling properties. *Z. mauritiana* has been used for thousands of years in traditional medicine to treat fever, diabetes, and skin conditions because of its antipyretic, antinociceptive, antioxidant, antibacterial, and insecticidal characteristics (Muhammad *et al*., 2022). The fruits are used as a liver tonic, as an antioxidant, hepatoprotective, protective effect, weight gain, increases stamina, and reported to have anticancer effects, while the leaves are used for hypoglycemic effects, reduction of sweetness judgments, as diuretic, emollient, expectorant, to promote hair growth, anticancer, sedative, blood purifier, and in the treatment of diarrhea (Tripathi and Preeti, 2014). Buttermilk and the calming properties of the seeds can ease pregnancy-related nausea, vomiting, and pain in the abdomen. Locals use the astringent seed to quench their thirst (Singh and Meghwal, 2020). A total of 431 chemical compounds (including those found in the fruits, roots, leaves, and stems) have been found in the *Ziziphus* species, according to Muhammad *et al.* (2022), of which polyphenols were isolated using a variety of extraction techniques and demonstrated a wide range of biological activities.

CONCLUSION

Ziziphus mauritiana is palatable and has high in energy, protein as well as minerals contents. Its vitamins and has antidiarrheal, antibacterial, immune promoting, and antioxidant properties. The inclusion of *Z. mauritiana* as a supplement or as a replacement can increase feed palatability, feed intake, and nutrient digestibility, and thereby improve the quality of animal products. Given its ability to improve immunity, and, thereby, to reduce the use of antibiotics, *Z. mauritiana* fruits and leaves has broad potentials uses in animal feed as a growth promoter, antioxidant, and flavoring agent. Finally, the recommended feeding levels as inclusion or supplement and processing technology should be improved by researchers.

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EFFECTS OF VARYING ENERGY REGIME ON GROWTH PERFORMANCE AND PRIMAL CUT CHARACTERISTICS OF NOILER CHICKEN

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ABSTRACT
The study was conducted at the Poultry Unit of the Teaching and Research Farm of the Department of Animal Health and Production, Binyaminu Usman Polytechnic, Hadejia, Jigawa State. The research focused on ascertaining the effects of varying energy regime on the growth performance and primal cuts characteristics of noiler birds. To arrive at the presented results, a total of seventy-two (72), day-old noiler chicks were procured and used for the eight weeks experiment. The chicks were randomly divided into three treatments with 24 chicks per treatment in a completely randomized design (CRD). Each treatment has four (4) replicates of six (6) birds per replication. Three (3) different experimental diets containing varying energy regimes of 2600MEkcal/kg, 2800MEkcal/kg and 3000MEkcal/kg were formulated and fed to T_1, T_2 and T_3 respectively. Water and the compounded feed were made available ad-libitum. The results showed that there were significant differences in average body weight gain, average final body weight and feed conversion ratio ($P<0.05$). However, no significant difference ($P>0.05$) was observed in all primal characteristics of the experimental birds across all the dietary treatments. It is concluded that, birds fed T2 diet (2800MEkcal/kg) has higher final body weight and feed conversion ratio with no distinctive feed intake. Moreover, varying energy regime has no effect on noiler birds primal cut parts. Hence, it is recommended for consideration while formulating noiler diet.
Keywords: *Energy, Noiler, Primal Cuts, Regime, Growth, Performance.*

INTRODUCTION
Poultry production is one of the best means for production of high biological value animal protein in terms of eggs and meat (Yakubu *et al*., 2007). The poultry sector contributes about 25% of the agricultural domestic products of the Nigerian economy (FAO, 2010). Nigeria presently produces above 550,000 mt of poultry meat per annum and 770,000 mt of eggs (FAO, 2010). The energy requirements of poultry and the energy content of feedstuffs are expressed in kilocalories i.e 1kcal equals 4.1868 kilojoules. Poultry like other farm animals consume feed primarily to satisfy their energy requirements (Oluyemi and Robert, 2007).

The feeding component of poultry farming is clearly a burden for farmer (Shiferaw *et al.*, 2013; Marangoni, *et al.*, 2015). This is due to the fact that poultry and humans have similar nutrition requirements, and that grains (such as corn) used in poultry diets are also consumed by humans. Besides, grains are also in competition with various industries as they are used as industrial raw material. In addition, the level of production of these important grains is not sufficient to meet the increasing demand of the poultry industry. Therefore, it is essential that scientific knowledge be improved on the utilization of low-cost and locally available materials in varying amounts and or proportion in poultry feed. This will help reduce the feed cost and increase profitability (Sissoko *et al.*, 2011). Body weight and a number of primal cut parts such as breast, shank, back, thigh, drumstick e.t.c have been applauded to be good indicators of body growth and value in noiler. Despite the Nigerian local chickens, not much information exist is comparing them with noiler which is an improved local breed. Thus, this research was embarked upon to evaluate the effects of varying energy regimes on growth performance and primal cut parts characteristics of noiler chicken.

MATERIALS AND METHODS

This research was conducted at the Poultry Unit of the Teaching and Research Farm of the Department of Animal Health and Production, Binyaminu Usman Polytechnic, Hadejia, Jigawa State (coordinates of 12º28'N /10º01'E).

Experimental Birds Management and Experimental Diets

Seventy-two (72), day-old noiler chicks were used in the experiment. The chicks were randomly divided into three (3) groups with twenty-four (24) chicks per treatment in a completely randomized design. Each treatment has four (4) replicates of six (6) chicks in each. The experimental diets were formulated with varying energy regimes (i.e. 2600MEkcal/kg, 2800MEkcal/kg and 3000MEkcal/kg) and the experimental diets were designated as T_1-600MEkcal/kg, T_2-2800MEkcal/kg and T_3-3000MEkcal/kg. The birds were fed with Ultima broiler starter feed in the first two weeks before placing them on the formulated experimental diets. The chickens were reared for 8 weeks. The birds were reared on a deep litter system, given Feed and water ad libitum and stricted bio-security measures were kept in place. All birds were vaccinated against Newcastle and Gumboro diseases. Coccidiostat, antibiotics and vitamins were also administered to birds.

Table 1: Composition of experimental diet (2-4weeks)

Ingredients	T_1(2600mekcal/kg)	T_2(2800mekcal/kg)	T_3(3000mekcal/kg)
Maize(kg)	42	50	60
Wheat offal(kg)	20	17	8
Soya beans meal(kg)	35	30	29
Limestone(kg)	0.7	0.7	0.7
Bone meal (kg)	1.30	1.30	1.30
Common salt (kg)	0.35	0.35	0.35
Vitamin premix (kg)	0.25	0.25	0.25
Lysine(kg)	0.20	0.20	0.20
Methionine(kg)	0.20	0.20	0.20
Total	100.00	100.00	100.00

Table 2: Composition of experimental diet (5-8weeks)

Ingredients	T_1(2600mekcal/kg)	T_2(2800mekcal/kg)	T_3(3000mekcal/kg
Maize(kg)	46	53	57
Wheat offal (kg)	15	12	11
Soya beans meal (kg)	28	28	29
Rice offal (kg)	8	4	-
Limestone(kg)	0.5	0.5	0.5
Bone meal (kg)	1.5	1.5	1.5
Common salt (kg)	0.35	0.35	0.35
Vitamin premix (kg)	0.25	0.25	0.25
Lysine(kg)	0.20	0.20	0.20
Methionine(kg)	0.20	0.20	0.20
Total	100.00	100.00	100.00

Data Collection

Average Daily Feed Intake: Feed given and the left over were weighed, the difference between the quantity of feed given and the left over, gave the daily feed intake for the previous day.

Average Body Weight: Initial body weights of each of the birds were taken before assigning them to the various treatments. Weekly measurement of body weight was also taken using a digital weighing scale.

Average weight gain: This was taken as the difference between the initial body weights and the final body weights of the birds. This measurement was carried out on weekly basis.

Feed conversion ratio: The quantity of feed consumed per unit increase in live weight. It is the reciprocal of feed efficiency and is estimated as:

FCR=feed consumed (g)/weight gain (g)

Primal cuts Characteristics: The head, neck, wing, breast, back, thigh, drumstick and feet were carefully dissected and their weights were obtained using sensitive electric weighing scale.

Data Analysis

The data generated were subjected to analysis of variance (ANOVA) in completely randomized design (CRD) of GENSTAT (2014), where significant differences between means were separated using Duncan Multiple Range Test.

RESULTS AND DISCUSSIONS

Growth performance of noiler chicken fed diets containing varying energy regime was presented in Table 3. The results revealed that there were no significant differences (P>0.05) in initial body weight and average feed intake among all the birds across the dietary treatments, however there were distinctive differences in final body weight, body weight gain and feed conversion ratio (P<0.05). Birds fed diet T1 reported in this research was found to be statistically better in final body weight and feed conversion ratio compared to the other treatments, this indicated that chicken reared on a moderate-level energy regime (2800MEkcal/kg) consume feed reasonably and convert it optimally. The present results are in contrast with the finding of Sheriff *et al.*, (1981) who obtained higher feed consumption in broiler fed 2950 kcal ME/kg ration. but agreed with the findings of Tooci *et al.* (2009) who compared concentrate diets (3010, 3150 and 3200 kcal/kg ME respectively for starter, grower and finisher phases) versus diluted diets (2800 kcal/kg ME) and reported that feed intake of broiler chickens was not influenced by energy content in diets, but concentrate diets improved weight gain and feed conversion.

Result of final body weight equally showed significant (p<0.05) difference where T2 appears to be the best among the treatments, the result obtained might be due to the fact that excess energy (glucose) in the diet is the major source utilized for storage as glycogen in animals Sheriff *et al.*, (1981). The body weight gain indicated that ration containing moderate energy, gained maximum growth. The higher level of energy was found to induce poor performance on body weight gain. The results are in agreement with Verma and Pal (2001) findings as moderate energy, and high protein had a positive effect on growth rate and was also reported by Bamgbose (1999). However, chicks fed diet with 3000 kcal ME/kg utilized feed more efficiently than the lower level of energy in the diet. As reported by Haunshi *et al.* (2012) that different ME levels had a significant effect on body weight gain, feed intake, and FCR.

Result of AFI obtained in this study showed no significant (p>0.05) difference, despite that there is numerical variation among the treatments, this finding also is at variance with the finding of Farrell *et al.* (1973) who concluded that the feed intake was inversely related to energy concentration in the diet.

Table 3: growth performance of noiler chicken fed diets containing varying energy regime

Parameters	Treatments			
	T_1 (2600MEkcal/kg)	T_2 (2800MEkcal/kg)	T3 (3000MEkcal/kg)	Pr<F
AIBW	318.8	329.0	329.8	0.55
AFBW	962.2^{ab}	1031.2^{b}	893.2^{a}	0.087
ABWG	644.0^{ab}	702.2^{b}	563.5^{a}	0.097
AFI	2022.0	2052.0	2102.0	0.33
FCR	3.20^{ab}	2.94^{a}	3.80^{b}	0.088

^{a,b,c}, Means with different superscript along the same rows are significantly (P<0.05)

ABWG= Average Initial Body Weight Gain, AFBW= Average Final Body Weight, AFI= Average Feed Intake,
Table 4 shows the effect of varying energy regimes on primal cut characteristics of noiler chicken. The result showed no significant (P>0.05) difference across the treatment groups in all the parameters (i.e., head, neck, wing drumsticks, thigh, breast and back) measured despite the slight numerical variations. This implied that varying energy regime has no any significant effect on primal cut value (Sese *et al*., 2013). While improvement in carcass was also recorded in noiler chickens fed by Kana *et al.* (2017). It is expected that the dietary energy levels would improve carcass yield as a result of better dietary amino acid digestion, which would favor muscle deposition, this agreed with Windisch *et al.* (2008) report that phytobiotics increased stabilization of intestinal health, animals are less exposed to microbial toxins and other undesired microbial metabolites such as ammonia and biogenic amines. As a result, animals are relatively relieved from immune defense stress during critical situations and there is increased availability of essential nutrients for absorption, thereby helping the animals to grow better within the framework of their genetic potential.

Table 4: Primal Cut Characteristics of noiler Birds Fed Diets Containing Varying Energy Regimes

Parameters	Treatments			
	T1	T2	T3	F pr.
Head	38.75	36.75	34.50	0.79
Neck	54.25	56.50	52.50	0.29
Wings	83.75	85.00	81.50	0.86
Breast	113.0	120.0	115.0	0.42
Back	10.25	116.0	98.00	0.87
Thigh	102.75	98.01	97.75	0.46
Drumsticks	87.50	87.75	82.25	0.44
Legs	49.25	47.75	43.25	0.54

$^{a, b, c, d}$ Means with different superscripts along columns differ significantly at (P < 0.05).

CONCLUSION AND RECOMMENDATION

It is concluded that, birds fed T2 diet (2800MEkcal/kg) has higher final body weight and feed conversion ratio with no distinctive feed intake, moreover, varying energy regime was found to have no effect on noiler birds primal cut parts. Hence, it is recommended for consideration while formulating noiler diet.

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PREVALENCE OF TICK INFESTATION IN SMALL RUMINANTS BROUGHT FOR SLAUGHTER AT THE KAZAURE ABATTOIR SLAUGHTER STAGE (CASE STUDY OF KAZAURE ABATTOIR)

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ABSTRACT

The research was conducted at Kazaure abattoir to determine the prevalence of tick infestation in small ruminants at pre-slaughter stage. For this purpose, a total of one hundred and thirty-four (134) small ruminants were examined in a systematic random sampling, were an average of twenty (20) small ruminants were randomly selected and examined every Saturday for a period of seven weeks, starting from 1st April, to 20th May, 2023.The prevalence of tick was determined by dividing the number of positive samples by the total sample size, and was expressed as percentages. The result revealed a prevalence 61.94% among the small ruminants brought in to the abattoir for slaughter. Regarding species, sheep were found to have higher prevalence (66.67%) than goats (59.04%); higher prevalence was recorded in female (68.57%) than male (56.04%). On the age side, adults were confirmed to have higher prevalence (75.34%) than young and old (47.83% and 44.74% respectively). Animals examined with poor body condition score has the highest prevalence (87.50%) compared to those with medium and good (68.57% and 46.27% respectively) body condition scores. The highest total prevalence (87.50%) confirmed among small ruminants with poor body condition brought to the abattoir seems to be as a result of poor tick control by the small ruminants rearers or salvaging decision taken by the rearers instead of controlling the condition. It was recommended that Extension workers should shed light to small ruminants rearers on treating ticks infested animals instead of salvaging, slaughtering of ticks infested animals should be discouraged to avoid transmission of zoonotic ticks borne diseases to meat consumers and good veterinary services should be provided in the study area.

Keywords: *Ticks, Small ruminant's abattoir, infestation, Kazaure.*

INTRODUCTION

The arthropods contain over 80% of all known animal species and occupy almost every known habitat, as well as a plethora of small and little-known groups. As a result of their activity, arthropod ectoparasites may have a variety of direct and indirect effects on their hosts (Wall and Shearer, 2001). Ectoparasites, particularly ticks, are important parasites because of their voracious blood-feeding activity and as vectors for various agents of diseases in both man and livestock (Cumming, 1998). In Nigeria parasites constitute a major constrain to livestock production (Fabiyi, 2007). This is particularly of cattle, sheep and goat. Ticks are ectoparasites of ruminants and other domestics and wild animals living by haematophagy on blood, causing skin irritation and anemia (Wilson, 1990).

Ticks are among the most difficult ectoparasites of domestic animals to control (Walker *et al.*, 2007). Ticks are also one of the major vectors of pathogens, such as Bebesiosis, Theileriosis, Anaplasmosis,Dermatophilosis etc to animals in the world (Soulsby, 1982; Morel, 1989). Severe irritations caused by their bites especially when numerous can result to severe emaciation as animals do not settle down to feed well. The large volume of blood they suck when they occur in large number can lead to anemia which in turn results in weakened stock. Their bites cause serious damage to hides and skins which are valuable export products in Nigeria (Fabiyi, 2007). The productivity of ruminant animals depends on the health status of the animals (Lamorde, 1981). Good herd health can only be achieved by adequate control of vectors of the diseases and this is one of the costly operations in the livestock industry. Effective control of vectors could be possible if farmers have the idea of infestation (Hassan, 1997). It is important to know the prevalence of the ticks species involved in the transmission as well as their geographical distribution for the control of ticks borne diseases (Gholan *et al.*, 2007).

All ticks are obligate temporary parasites of vertebrate animals in which they cannot survive without blood. Larvae, nymphs and adults, both males and females need to suck blood and are characterized by a complex developmental cycle. Ticks thus can become integrated into the epidemiological chain of pathogen transmission, by means of the so-called trans-stadia (stage-to-stage, also called horizontal) or transovarial (female-to-egg, also called vertical) passages (Kahl *et al.*, 2002). Ticks feed on concentrate blood meal by removing the excess water. This helps to accommodate the large blood intake (several milliliters) in the relatively small body. The engorgement and blood sucking habit, longevity, high reproductive potential, relative freedom from natural enemies and highly sclerotized bodies that protect them from environmental stress contributed to their successful life (Estrada-Peña *et al*., 2013).

Ticks may have multi-year life cycles, long starvation tolerance and various stages may survive over winter. Slow intracellular digestion of blood allows for pathogens to escape digestive process in the ticks' gut and protects pathogens in an intracellular location. An early painless bite, saliva containing pharmacologically active compounds mediating the host immune response and anticoagulant compounds allowing continued blood flow into feeding lesions all contribute to effective tick parasitism (Gary and Lance, 2009). The objectives of the study therefore were to investigate the prevalence of ticks on small ruminants brought for slaughtering at the Kazaure abattoir with respect to species, sex, age and body condition and to understudy the most susceptible small ruminants to ticks.

The Study Area

The research was conducted in Kazaure Abbatoir, in Kazaure town, Kazaure Local Government Area of Jigawa State, Nigeria. Its headquarters is in the ancient city of Kazaure, it is also an Emirate Which Comprises Kazaure, Roni, Gwiwa And Yankwashi Local Governments.

Sampling Procedure

A total of one hundred and thirty-four (134) small ruminants were examined in a systematic random sampling during the course of this research, an average of twenty (20) small ruminants were randomly selected and examined every Saturday for a period of seven weeks, starting from 20th April to 2nd June, 2023.

Data Collection

The Data was obtained by physical examination of the animals kept in the pens of Kazaure abattoir for the presence of tick. Species, sex and body condition scores (BCS) of the small ruminants were determined at the time of collecting the data. Ticks were checked on different parts of the body including the neck/dewlap, eyes, ear, udder and external genitalia, inner thighs, under the tail/perineum and legs /inter digital spaces by using forceps and gloved hands. The age of the animals were categorized as young (0 up to 1 years), adult (2 up to 4 years) and old (above 4 years old) according to the classification method used by Gatenby (2002). Those small ruminants on which tick were seen were marked as positive.

Data Analysis

The data obtained were analyzed using simple descriptive statistics such as means and percentages. The prevalence of tick was determined by dividing the number of positive samples by the total sample size, and was expressed as percentages.

RESULTS AND DISCUSSION

A total of 134 small ruminants (51 sheep and 83 goats) were examined to determine the prevalence of tick infestation in small ruminants at the Kazaure abattoir. Of these 83(61.94%) of the examined small ruminants brought to the abattoir for slaughter were infested by tick. Based on species, sheep were found to have higher prevalence (66.67%) than goats (59.04%),higher prevalence was recorded in female (68.57%) than male (56.04%).On the age side, adults were confirmed to have higher prevalence (75.34%) than young and old (47.83% and 44.74% respectively). Animals examined with poor body condition (i.e. itching, scratching and visible red or inflamed irritations on the skin) score has the highest prevalence (87.50%) compared to those with medium and good (68.57% and 46.27% respectively) body condition scores. The highest total prevalence (87.50%) confirmed among small ruminants with poor body condition brought to the abattoir seems to be as a result of poor tick control by the small ruminants rearers or salvaging decision taken by the rearers instead of controlling the condition.

Table 1: Prevalence of tick infestation in small ruminants at the Kazaure abattoir with respect to species, sex, age and body condition scores

Variable	Categories	No.of animals examined	No.of infested animals	Prevalence
Species	Sheep	51	34	66.67
	Goats	83	49	59.04
Sex	Male	64	36	56.25
	Female	70	47	68.57
Age	Young	23	11	47.83
	Adult	73	55	75.34
	Old	38	17	44.74
	Poor	32	28	87.50

BSC	Medium	35	24	68.57
	Good	67	31	46.27

BCS=Body Condition Scores

DISCUSSION

The current study revealed that tick infestation is widespread and amongst the most significant external Parasites of small ruminants in the study area. The result of this study revealed a relatively low prevalence (61.94%) of tick infestation on small ruminants compared to the reports of Ahmed *et al.* (2017) who investigated the prevalence of ticks on small ruminants in Beadle district, Oromia Region, of Ethiopia. In the report, tick prevalence as high as 76.50% was reported in small ruminants. However, tick prevalence of 66.12% (goats) and 80.30% (sheep) was recorded in Bedelle district, Oromia Region, Ethiopia by Abunna *et al*. (2009). The higher prevalence recorded in female (68.57%), than that of male (56.04%) in this study agrees with the findings of Ahmed *et al*. (2017) who reported 59.34% in female and 70.47 in females. The animals examined with poor body condition score in this study has the highest prevalence (87.50%) compared to those with medium and good (68.57% and 46.27%, respectively) body condition scores, this agrees with report by Ahmed *et al*. (2017) and (Aminu, 2015). Some ticks species have preference for the host species (host specific) while some species can affect all species of livestock (McCoy *et al*., 2013). Attention should be given to the prevention and control of ticks since they served as vectors to livestock diseases and caused damage to the skin of animals.

CONCLUSION

The results obtained revealed a moderate overall prevalence of 61.94%, and amongst the variables. Higher prevalence (87.50) was observed among small ruminants with poor body condition score among the animals brought to the abattoir for slaughter.

RECOMMENDATIONS

i. Extension workers should shed light to small ruminant's rearers on treating ticks infested animals instead of salvaging.
ii. Slaughtering of ticks infested animals should be discouraged to avoid transmission of zoonotic ticks borne diseases to meat consumers.
iii. Good veterinary services should be provided in the study area.
iv. The farmers should be encourage to go for veterinary services.

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ANALYSIS OF FACTORS AFFECTING POULTRY EGG PRODUCTION EFFICIENCY IN ETIM EKPO LOCAL GOVERNMENT AREA, AKWA IBOM STATE, NIGERIA

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ABSTRACT
This study analysed the factors affecting poultry egg production efficiency in Etim Ekpo Local Government Area. The objectives of the study were to describe the socio-economic characteristics of poultry egg producers and factors affecting Poultry egg production efficiency in the study Area. Multistage sampling procedure was adopted to collect primary data from seventy-five (75) poultry egg producers using a well-structured questionnaire. Percentage, frequency count, average and ordinary least square regression were employed to analysed the data in the study area. The result of the findings revealed that, majority about 71% of the poultry egg farmers in the study area were male. The average age of the respondents in the study stood at 41 years, The study revealed that, the respondents in the study area had one form of education or the other. It was also discovered that most of the farmers were married about 83%. The means household size stood at 4 persons per household. 76% of the respondents were members of cooperative society. The mean income of the respondents stood at ₦70,800 per month. The result also revealed that majority, about 99% of the respondent had farming as their major source of income. From the findings of the study, it was concluded that there was a significant relationship between input and output in poultry egg enterprise. The study recommends, the integration of poultry egg production programmes to geared towards empowerment, better management practices, subsidy on poultry equipment and credit facilities and encouragement of farm records keeping for high production efficiency attainment.
Keywords: *Analysis, Factors, Poultry, Egg Production, Efficiency*

INTRODUCTION
The poultry industry is significant to the Nigerian economy at large and the rural economy in particular because it provides a good source of meat and eggs which supplies animal protein to the human diet. Proteins play key roles in the formation of a balanced human diet that is essential for better health, vigor, and productive capacity of the people. It builds and repairs body tissues; a low intake or deficiency of protein reduces the skillfulness of the young, hinders the development of the brain, retards rate of growth and increases rate of susceptibility to infections by animals. Ijah, Ishola, Ayodele, Yahaya, and Olukotun, (2020).
The poultry sector is one of the most organized and vibrant segments of the agriculture industry in Nigeria, which strives harder towards the provision of much protein human diet. This sector generates direct and indirect employment and income for many people not leaving out the generation of revenue to the overall economy. Ijah *et al.,* (2020). Tijani *et.al.* (2012) reported that eggs have many uses apart from domestic consumption in households; eggs are used in confectionery, bakery products, ice cream, and cosmetics. Egg shell is a good source of calcium for the formation of strong bones and teeth. Nutritionally, eating an egg per day is a good way of putting proteins, fats, vitamins and minerals in human diet. According to Mere, Ater, and Ezihe, (2017), a medium sized egg supplies about 80 calories of energy to our body. They further asserted that egg contains not only a trace of carbohydrate, but it was also adjudged to be a replacement for meat as it contains all essential amino-acids in adequate proportion required by the body for general growth and repair.
Efficiency of poultry egg production is defined as the ability of a poultry egg producer to achieve the highest possible quantity of egg, return and profit given the prices and levels of all input factors as well as the prevailing technology which will enable the farmer to operate along the production possibility frontier. Research carried out on the Efficiency of Poultry Egg Production in some areas revealed impressive results as follows: Hassan *et al.,*

(2016) examined the input-output relationship and cost and return in egg production in Kaduna state using descriptive statistics, multiple regression, cost and return analysis. The result revealed that, the total cost of production was N206, 610. 44 per 100 layers and net farm income was N208, 079. 75. The return per Naira invested was N1.01. Feed cost accounted for 69% of the total cost of egg production. The regression result revealed that all the parameters estimated except labour (-0.742) carry positive sign. Which implied that flock size (1.287), feed (0.911) and medication cost (0.305) have direct relationship with the farmer's egg output. The t-ratios showed that flock size, and feed were significant at 5% and 10% level of significance respectively.

Ayinde *et al.*, (2012) examined the economics value of poultry egg production under different management systems in Odeda Local Government Area of Ogun State in 2008 using a combination of descriptive statistics, budgetary techniques, profitability ratios and multiple regression analysis. The study results showed that the Gross Margin under battery cage system per bird / year was N8, 089.56, while the Net Farm Income per bird / year was N1, 773. 17. Under deep litter system, the Gross Margin per bird / year was N1, 404.09, while the Net Farm Income per bird / year was N1,029.43. The regression result showed that educational qualification (α0.10), total feed used (α0.05), total labour used (α0.05), and the stock size (α0.01), were significant determinants affecting the quantity of egg produced.

The study of technical efficiency in small and medium scale poultry, egg production in Ogun State, Nigeria was reported by Akerele *et al*. (2019). The results on age showed that the mean age of the producers is 43 years with higher percentage of the farmers being relatively young and in their active age of production. The implication is that younger farmers are likely to adopt innovations faster than the older ones. The result on farming experience revealed a mean experience of 9.8 years, with majority (67.7%) having 10 and below years of experience. The mean flock size of chicken table egg farmers in the study area was found to be 1040 birds. Analyses of household size of the producers showed a mean household size of 7 persons with a modal household size of ranges of between 6 and 10 persons. The high mean household size means that there is high availability of family labour to the enterprises in the study area. The result on marital status showed that majority (78.5%) of the sampled producers were married. This shows that the producers are responsible according to the societal standard and therefore are likely to have some experience of life challenges which instills some level of discipline in making decision. On educational status of the producers, the result shows that majority (69.2%) of the producers had tertiary education indicating that they are highly educated. The result on occupational status showed that most of the respondents (53.8%) in the enterprise were engaged in the eggs production venture as their secondary occupation.

The estimation of the efficiency of poultry-egg farmers in Ondo State was reported by Oluyemi *et al*. (2020). The findings showed that 81.7% of the farmers were male and the mean age was 46.2. Most of the respondents constituting about 90.4% were married and majority (84.3%) had tertiary education. 68.7% of the respondents had access to credit facility. The profitability analysis showed that feed constituted the highest variable cost item. Small scale enterprise spent 83.80% on feed, medium scale spent 85.18% while large scale incurred 76.41% on feed. The technical efficiency result showed that 40.9% of the respondents were most efficient. The mean technical efficiency of the farmers was 83.1% while the minimum and maximum efficiencies were 13% and 97% respectively. About 3.5% of the respondents were below 50% economic efficiency and the mean economic efficiency was 0.771. The allocative efficiency analysis revealed that farmers were at least 50% efficient and the mean allocative efficiency was 0.948. Inefficiency result showed that feed and stock had significant influence on egg production at (P=0.1). High cost of input was rated the major constraint and inadequate storage facilities was rated as the least constraint.

Apart from poultry industry being so significant to the Nigerian economy, it also provides a good source of meat and eggs supplies of animal protein to the human diet. The proteins play key function in the formation of a balanced human diet that is essential for better health, vigor, and productive capacity of the people as well as building and repairing of body tissues. While low intake or deficiency of protein reduces the skillfulness of the young ones, hinders the development of the brain, retards rate of growth and increases rate of susceptibility to infections (Ijah *et al.,* (2020)). It is on this ground that this research study is necessary to analysed the factors affecting poultry egg production efficiency in Etim Ekpo Local Government Area. The specific objectives are to; assess the socioeconomic characteristics of poultry egg producers and ascertain the factors affecting poultry egg production efficiency in the study area.

RESEARCH METHODOLOGY

This study was conducted in Etim Ekpo L.G.A of Akwa-Ibom State, coordinate is $5^0$1'N $7^0$37'E. The L.G.A was created out of the former Abak division, Etim Ekpo is one of the Annang-speaking natives. The seat of the local government council is in Utu Etim Ekpo a community in Etim Ekpo. The inhabitants of this town are estimated to be 108,418, according to 2006 population census. This figure was projected to 112,660 people in 2021. Etim Ekpo local government area is made up of four districts of seventy-four communities and villages. The people of this locality are predominantly subsistence farmers, traders and craftsmen. Natural resources in Etim Ekpo local government area are sharp sand, gravel, timber and oil-palm. The people of Etim Ekpo are mainly farmers, but the educated indigenes work as civil servants within and outside the local government area. In the area of education, there are many public and private secondary schools. The local government area is the home of one private university, the Obong University, located at Obong Ntak. The people of Etim Ekpo are vast in knowledge and every other creative activity (Wikipedia, 2021). A multistage sampling technique was adopted in this research. The first stage was a purposive selection of five (5) clans in Etim Ekpo Local Government Area. The second stage, was a simple random selection of five (5) villages from each clan. The third stage was a simple random selection of three (3) poultry farmers in each of the five villages. The total respondents for the research were 75 poultry farmers. Both descriptive and inferential statistics were used in the analysis. Descriptive statistics such as percentages, frequency counts, arithmetic means and tables were employed in analysing the socioeconomic characteristics of the farmers. While, OLS regression was used to analysed the factors affecting poultry egg production efficiency in the study area.

RESULTS AND DISCUSSION

Socioeconomic Characteristics of Poultry Egg Farmers in the Study Area

The Result in Table 1 below shows that majority about 71% of the poultry egg farmers in the study area were male while minority about 29% were females. This indicated that the males were more involved in poultry egg production in the study area than their female counterparts. This finding is in line with the finding of Ijah *et al.*, (2020) and Oluyemi *et al.* (2020) who discovered that the poultry egg producers were predominately male in their study areas as expected because of the energy demanding nature of the poultry enterprise.

Age is an indication of the stage of life of the respondents as well as how active a respondent could be especially in poultry egg farming activities. Table 1 also reveal that 29 farmers fell within the age range of 25-36 years representing about 38% of the total respondents, 31 farmers fell within the age range of 37 – 48 years representing about 41% of the total respondents and 15 farmers fell within the age range of 49-60 years representing about 20% of the total respondents. While the average age of the respondents in the study was 41 years. This is an indication that the farmers as at the time of this research were at their prime and active stage of their life existence, as such being able to cope with the tediousness involved in the poultry egg production as well as adaptation of new techniques for production. This age status will enhance their rate of production efficiency which will lead to increase in income to enhance more profit. This is confirming Akerele *et al.* (2019) that, the mean age of the producers is 43 years with higher percentage of the farmers being relatively young and in their active ages of production which, implied that the younger farmers are likely to adopt innovations faster than the older ones.

On the aspect of educational attainment, Table 1 further revealed that, about 11% of the respondents had First School Leaving Certificate (FSLC), majority representing about 39% of the respondents had West African Examination Certificate/ West African Senior Secondary Certificate Examination (WAEC/WASSCE), 16% acquired Ordinary National Diploma (OND), about 13% of the farmers had the National Certificate in Education (NCE), 20% had higher National Diploma (HND) while only about 1% had either Bachelor of Art or Bachelor of Science (BA/B.Sc.), respectively. The figure depicts that, the respondents in the study area had one form of education or the other. This implied that their educational status has significantly contributed to the increase in poultry egg production efficiency in the study area whereby enhanced high-income generation. This is in line with Akerele *et al*. (2019) findings that, the level of education of the producers will contribute significantly to their decision making.

The findings further revealed that most of the farmers were married about 83%, while about 17% were single. This is in line with Akerele *et al*. (2019) who revealed that, majority (78.5%) of the sampled producers were married with implication that the producers are responsible according to the societal standard and therefore are likely to have some experience of life challenges which instills some level of discipline in making decision. The study depicts that majority, about 75% of the respondents had household size that ranged between 3 – 4 persons, followed by about 21% of the respondents fell within 5-6 persons and 4% had 1-2 persons in their household. While the means household size stood at 4 persons per household, indicating that the household size is small within the African context.

Results on cooperative society membership revealed that, majority (76%) of the respondents do not belong to any cooperative society while only 24% of the respondents belong to one cooperative society or the other. This may be the reason why some of them were unable to accessed loans to increased their production capacity. Majority, about 69% of the poultry egg farmers in the study area acquired monthly farm income ranges from ₦20,000 – ₦80,000. This was followed by about 27% of the respondents who got income ranges from ₦81,000 –₦140,000 per month. Only 4% of the respondents acquired the ranges of income between ₦140,000 – ₦200,000 per month. While, the mean income stood at ₦70,800 per month, this level of income may be as the result of the high cost of production inputs. The result also revealed that majority, about 99% of the respondents had farming as their major source of income while only 1% of the respondents had income from civil Service work as well as farm work. This result may not be far from the average age status of 41 years, being young and active to perform farm work as well as their literate levels which will enable them to adopt innovation faster. Another reason for the respondents to take farming as their major source of income may be due to lack of white-collar jobs for the teeming youths' population that make them to resort to farming as their last option.

Table 1: Distribution of Egg Producers Based on Socio-economic Characteristics

Item	Variables	Frequency (n = 75)	Percent	Mean
1	**Sex**			
	Male	53	70.7	
	Female	22	29.3	
2	**Age**			
	25 – 36	29	38.7	
	37 – 48	31	41.3	41
	49 – 60	15	20.0	
3	**Educational Level**			
	FSLC	8	10.7	
	WAEC/WASSCE	29	38.7	
	OND	12	16.0	
	NCE	10	13.3	
	HND	15	20.0	
	BA/BSc	1	1.3	
4	**Marital Status**			
	Single	13	17.3	
	Married	62	82.7	
5	**Household Size**			
	1 – 2	3	4.0	
	3 – 4	56	74.7	4
	5 – 6	16	21.3	
6	**Total Membership in Cooperative Society**			
	Yes	18	24.0	
	No	57	76.0	
7	**Monthly Farm Income (₦)**			
	20000 – 80000	52	69.3	
	80001 – 140000	20	26.7	70,800
	140001 – 200000	3	4.0	
8	**Major Source of income**			
	Farming	74	98.7	
	Civil Servant and Farming	1	1.3	

Source: Field survey, 2021.

The Factors Affecting Poultry Egg Production Efficiency in the Study Area

This subsection analyzed factors affecting egg production in the study area as shown in table 2. The result revealed that out of the four functional forms tried, exponential production form was chosen as the lead equation for the analysis based on conformity with a priori expectation of signs, magnitude of coefficients, overall significance of the functional form (F-statistics) as well as the explanatory power of the variables (adjusted R^2) included in the model. The F –value is statistically significant at 10% level which implies that the independent variables (X_1 to X_{12}) included in the model best explained the dependent variable (Y), value of egg production. The R^2 was 0.267 which implied that the regression model gives a good fit. It means that 26.7% of the total variations in value of egg production was explained by the independent variables (Xi) included in the model.

The results also show that factors such as cost of feeds, and membership in cooperative were the major factors that affected the value of egg production because they have shown a statistically significant effect at 5% and 1% levels respectively. The implication is that 5% reduction in feed cost will lead to about 37% increase in output while 1% increase in the membership cooperative, can increase value of egg production by 28% in the study. This may be due to the fact that cooperative members can easily access loans from financial institutions as well as obtaining firsthand information agricultural production activities. This is in line with the a priori expectation that the higher the exposure to social capital, knowledge, and economics of cooperate entrepreneurship involvement, the higher the returns from egg investment opportunities. The coefficients of other variables even though were not statistically significant were ether positively or negatively related to the poultry egg production efficiency in the study area.

Table 2. Factors Affecting Poultry Egg Production Efficiency in The Study Area

Variables	Linear	Exponential	Double- log	Semi-log
(Constant)	-1304953.818	13.507	13.222	-20624647.773
	(-.137)	(9.221) *	(1.044)	(-0.255)
X_1 Age (in years)	0.108	0.042	-0.016	0.065
	(0.514)	(0.215)	(-0.078)	(0.302)
X_2 Education (years)	-.0129	-0.129	-.138	-0.099
	(-0.832)	(-0.889)	(-0.910)	(-0.621)
X_3 Farming experience (years)	-0.082	-0.026	-0.007	-0.028
	(-0.513)	(-0.171)	(-0.043)	(-0.171)
X_4 cooperative membership (1= yes, 0 = no)	0.232	0.283 ***	0.271***	0.217
	(1.494)	(1.944)	(1.723)	(1.314)
X5 access to credit (1=yes, 0= no)	0.099	0.165	.0168	0.085
	(0.713)	(1.274)	(1.214)	(0.591)
X_6 Sex (1=Male, 0= Female)	-0.096	-0.018	0.009	-0.072
	(-0.618)	(-0.124)	(.058)	(-.445)
X_7 marital status)1=married, 0=unmarried)	-0.195	-0.128	-0.111	-0.193
	(-1.337)	(-0.936)	(-.738)	(-1.219)
X_8 households' size (no. of people)	0.167	0.183	0.243	0.202
	(.965)	(1.127)	(1.444)	(1.144)
X_9No. of birds	-0.103	-0.100	-0.069	-0.083
	(-0.695)	(-0.721)	(-0.423)	(-.485)
X_{10} cost of drug and vet services	-0.159	-0.042	-0.106	-0.181
	(-1.247)	(-0.353)	(-0.847)	(-1.379)
X_{11} cost of feed	0.278**	0.366**	.236***	0.161
	(2.224)	(3.120)	(1.899)	(1.234)
X_{12} Cost of Labour	0.023	-0.015	-0.034	0.019
	(0.176)	(-0.125)	(-0.263)	(.0143)
Diagnostics				
R	0.407	0.517	0.446	0.344[a]
R^2	0.166	0.267	.0199	0.119
Adj. R^2	0.005	0.125	0.044	-0.052
Std. Error of the Estimate	3850724.19398	0.59379	0.62075	3958507.07410
F-Statistic	1.028	1.880*	1.281	0.696
Sig	0.435	.055	.252	0.749

(***) = 1% significant level, (**) = 5% significant level, (*) = 10% significant level

CONCLUSION AND RECOMMENDATIONS

Based on the findings from the study, it was concluded that there is a significant relationship between input and output in poultry egg enterprise as well as poultry farming being a profitable venture in the study area. With the continues rise in demand for poultry egg in the study area, investment in poultry egg production is a viable enterprise for income generation, job creation especially, poverty alleviation and enhancement of food security in line with the poultry value chain transformation action plan of the on-going agricultural transformation agenda of Nigeria.

In the light of the research findings, the following recommendations are hereby proffered: Adequate measures aimed at reducing the cost of poultry egg production through research in the study area, especially the cost of feeds which constituted the largest proportion of the total cost of commercial poultry egg production, that will help in increasing egg production efficiency of the commercial poultry farmers in the study area and the nation at large. Poultry egg production should be integrated as a vital component in government programs geared towards empowerment especially for the teeming unemployed youths in the state as well as the nation due to its profitability. To increase the rate of production efficiency, better management practices should be implemented, feed should be formulated locally to reduce feed cost. Importers and manufacturers of poultry equipment should be given subsidy and credit facility respectively to reduce their importation and production cost, thereby enhance high rate of production efficiency. Poultry egg producers should be encouraged to keep records of sales, purchase in order to determine their productive performance which will eventually lead to production efficiency

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GROWTH PERFORMANCE OF UDA RAMS FED DIET CONTAINING GRADED LEVELS OF MILLET STALK MEAL (MSM) IN ALIERO LGA OF KEBBI STATE, NIGERIA

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ABSTRACT
The research was conducted to evaluate the growth performance characteristics of Uda rams fed diets containing graded levels of millet stalk meal (MSM) as a replacement for cowpea husk. Twelve (12) entire Uda rams were used in this experiment, the animals were housed in 2m x 1m pen and randomly allotted into three experimental diets designated as; T1(control diet), T2 and T3 containing 0 %, 50 and 100 % respectively of MSM as a replacement for cowpea husk. Each treatment was replicated four times with one ram per replicate in a completely randomized design (CRD). Data were collected on feed intake, body weight gain, feed conversion ratio (FCR). The experiment lasted for 12 weeks. All the parameters measured indicated a slight decreased in values as the level of levels of MSM increases in the diet. The results of feeding graded level of MSM to Uda rams showed a comparable performance in terms of feed intake, body weight with those on the control diets. The highest feed intake (846.79g/d) and final body weight (32.05kg) were recorded in treatment 1. However, there was no significant (p>0.05) differences in the dry matter intake and dry matter intake as percentage body weight. The optimum weight gain and efficient utilization of the diet was achieved in treatment 2 (6.78kg) at 50% inclusion level of MSM when compared with treatment 3 (3.95kg). The highest feed cost (₦57.96k) was recorded in the control diet while the least (₦52.96k) was obtained in treatment 3 This study indicated that millet stalk meal could be incorporated into the diet of growing Uda rams up to 50 % replacement with cowpea husk at a reduced cost is recommended for intensive feeding of Uda rams without any deleterious effect on their growth performance.
Key words: *Growth performance, Uda rams, Millet Stalk Meal*

INTRODUCTION
Inadequate availability of feeds and forages due to reduction in area and deterioration of grazing lands poses a serious threat to sheep production in the Nigeria, it is one of the major problems facing the stock owners especially during the long dry season which is experienced in the northern part of Nigeria (Williams *et al*., 1997). Large scale production and utilization of crop residues is most common in the northern savannah environment which has the advantage to reduce the cost of feeding ruminants especially during the dry season period (Onwuka *et at*., 1997).

Crop residues of cereal origin are generally of poor quality due to high fiber content, low protein and low digestibility. They are poorly utilized when fed alone to ruminants but can be highly utilized when fed along with other conventional ingredients (Heuze and Tran, 2013). Therefore, the present study was carried out to evaluate the potential of millet stalk meal at graded levels on the growth response of Uda rams.

MATERIALS AND METHODS
Experimental site
The study was conducted at the Livestock Teaching and Research Farm (LTRF) of Kebbi State University of Science and Technology, Aliero. The Farm is located within the campus of the University around Zoological Garden. Aliero Local Government Area lies at latitude 12°16′44″N and Longitude 4°27′6E. The annual temperature varies considerable but usually between 26°and 38°C while the mean annual rain fall is about 500mm. The town has the largest onion market in Northwest Nigeria. The predominant ethnic group of the area is Hausa (KARDA, 2012).

Experimental animals and their management
Twelve (12) entire male Uda rams of ±24.45kg average weight, were purchased from a local market in Kebbi State for the fattening. The animals were group fed with cowpea hay and wheat offal for a period of two weeks before the commencement of the study. The rams were balanced for weight before being allotted to treatments

and were dewormed with anthelmintic (Ivomec) at the rate of 1ml/10kg body weight. They were Sprayed against ecto-parasites with Triact and treated with oxytetracycline HCL (a broad-spectrum antibiotic). Experimental animals were house in an individual pen measuring 2m ×1m. The pens were clean and disinfected with Izal solution. Prior to the commencement of the experiment, the animals were managed intensively and group-fed with cowpea hay and wheat offal.

Experimental diets preparations and formulation

The test ingredient (millet stalk) was, purchased from local farmers at Aliero local government area. The millet stalk was grinded using crushing machine. Other feed ingredients that were used in the preparation of the experimental diets including groundnut cake, cowpea husk, salt, rice bran and maize, salt and other feed ingredients were purchased from Aliero Market.

Three complete experimental diets were formulated using varying levels of millet stalk to replace cowpea husk at 0, 50, and 100 % levels of inclusion and were designated as diets 1, 2, and 3 in the experiment. Variation in composition of some feed ingredients was made in order to balance up the crude protein and energy.

Table 1: Ingredients Composition (g/kg DM) of the Experimental Diets

	Treatments		
Parameters (%)	1 (0%)	2 (50%)	3 (100%)
Maize	13	14	14
Wheat Offal	17	12	19
Rice Bran	29	25	23
GNC	18	20	21
Cowpea husk	22	11	0
Millet stalk	0	11	22
Salt	1	1	1
Total	**100**	**100**	**100**
Calculated value			
Cp (%)	13.91	13.21	12.16
ME (Kcal/kg)	2169.8	2153.5	2140.1
Feed cost (₦/kg)	57.96	55.74	52.19

Experimental design and feeding procedure

A Complete Randomized Design (CRD) as outline by Gomez (1984) was used in this experiment. Four (4) rams were allotted as replicates to three experimental diets as treatment in the feeding trials. Each ram was individually house in a pen. Each group of four animals were assigned to one experimental diet and fed at 3% of its body weight for 12 weeks. The animals were weight weekly between 8:00am and 9:00am for the period of the experiment. Daily records of feed intake were taken for twelve weeks of feeding trial by measuring the feed offered and that of the Left over. The basal diet was served and water was offered ad libitum to each animal for 12 weeks.

Data Collection

The animals were weighed before the commencement of the experiment and every week on the same day of the week between 8.00 and 9.00am after feed withdrawal for 14-16 hours to avoid error due to gut fill. Daily record of feed intake and weekly body weight gain were taken throughout the 12 weeks of the feeding trials.

Data Analysis

The data generated on the performance characteristics which include feed intake and live weight changes and were subjected to Analysis of Variance using the Statistical Package for the Social Sciences SPSS (2007) 16.0 software. Tukey`s-b Test was used to separate the treatment means.

RESULTS AND DISCUSSION

The results of the calculated feed cost obtained (Table 1) indicated that the cost of feed per kg decreased as the MSM increases in the diet with the control diet having the highest value (₦57.96k) while the least value was recorded in treatment 3 (₦52.19k). The decreased in cost is an indication of MSM potential in the diet of Uda rams. This is in line with the findings of Maigandi *et al*. (2002). The results in Table2 Indicates the performance measurement of the Uda rams fed diets containing millet stalk meal. The final body weights showed a non-significant (P>0.05) difference across the treatments with treatment 1 having the highest value (32.05kg) while treatment 2 (31.03kg) was higher than treatment 3 (28.38kg). The highest value was recorded in treatment 1 (7.825kg) and the least value was obtained in treatment 3 (3.950kg). The value obtained were statistically significantly different (P<0.05) across the treatments.

The results of the daily feed intake were similar (p>0.05) for treatment 1 (846.79g) and treatment 2 (822.92g). However, both had values which were significantly different (P<005) from treatment 3 (735.27g). The results of this experiment indicate a decreased in feed intake and weight gain with increased levels of millet stalk meal in the diets. The decrease in feed intake with increasing levels of millet stalk meal in the diet, could be due to the fact that millet stalk meal is characterized as low quality roughage which tends to be eaten less by animals to satisfy their needs for energy and other nutrients (McDonald *et al*., 1995).

The feed conversion ratio was significantly ($p<0.05$) affected across the treatments. The values (0.11, 0.09 and 0.07) obtained for feed conversion ratio were lower than the values reported by Ochepo *et al.* (2012) when goats were fed complete diet containing sugar cane peels. These results agreed with the report of Abubakar (2016). Who reported that feeding rams with crop residues alone could lead to an apparent loss of weight. The dry matter (DM) intake recorded for both treatments were not significantly ($p>0.05$) different across the treatment. The highest DM intake recorded were statistically the same across the treatments. However, treatment 3 had the highest value (92.25) while the least was obtained in the control diet. The DM intake increase as the level of MSM inclusion in the diets increases. This present finding is in agreement with Abdul *et al*. (2008) in their study on the effects of supplementing sorghum stover with poultry litter on the performance of Wadara cattle where they reported that supplementation with poultry litter significantly ($P<0.05$) increased dry matter intake (DMI). The dry matter as percentage body weight gain was not significantly ($p>0.05$) different across the treatments. The DM intake as percentage of body weight increases as the inclusion level of MSM in the diets increases. Treatment 3 had the highest value of 325.97% while the treatment 1 had the least value of 287.58%

Table 2: Performance characteristics of Uda rams fed experimental diets

Parameters (%)	Treatment 1(0%)	2(50)	3(100)	SEM
Initial body Wt. (kg)	24.23	24.45	24.43	1.49
Final body Wt. (kg)	32.05	31.13	28.38	2.13
Feed intake (g/day)	846.79^{a}	822.92^{a}	735.27^{b}	13.98
Av.Feed intake (kg)	72.04^{a}	68.76^{ab}	57.04^{b}	4.29
Feed conversion ratio	0.11^{a}	0.09^{ab}	0.07^{b}	0.012
Dry matter intake	90.00	92.00	92.25	0.68
Dry Matter intake as % body weight	287.58	299.87	325.97	21.01

abc: means in the same row followed by the same superscripts were not significantly ($p>0.05$) different

CONCLUSION

This study indicated that millet stalk meal could be incorporated into the diet of growing Uda rams up to 50% replacement with cowpea husk at a reduced cost as compared to the control diet is here by recommended for intensive feeding of Uda rams without any deleterious effect on their growth performance.

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GROWTH PERFORMANCE OF FINISHER BROILERS FED GRADED LEVELS OF VEGETABLE REFUSE AS DIETARY SUPPLEMENT

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ABSTRACT
A 28 day feeding trial was conducted at the Teaching and Research farm of the Department of Agriculture, Alex Ekwueme Federal University Ndufu Alike Ikwo Ebonyi state, to evaluate the growth performance of finisher broilers placed on graded levels of vegetable rejects as dietary supplement. Five (5) treatment diets were formulated such that the homogenized vegetable rejects (VR) was incorporated into the treatment rations at graded levels notably T_1 (VR_0), T_2 ($VR_{1.0}$), T_3 ($VR_{1.5}$), T_4 ($VR_{2.0}$), and T_5 ($VR_{2.5}$) respectively. The birds were divided into 5 groups of 18 birds per treatment, replicated 3 times with 6 birds per replicate. The treatment diets were randomly assigned to experimental stocks in a Completely Randomized Design (CRD). The results obtained from this study indicated that VR had a significant effect ($P<0.05$) on growth, average daily feed intake and cost per kilogramme weight gain of finisher broilers. It was established from the study that VR should be included as a supplement at 1.0% level for optimum performance so as to make animal protein available at a reduced cost and maximized profit.

INTRODUCTION
Poultry industry in Nigeria contributes about 25% of the Agricultural Gross Domestic Product of the economy and employs over 25 million Nigerians directly and indirectly (Nigerian Tribune, 2023). Poultry production as an enterprise is now attractive and popular among small, medium as well as large scale livestock farmers. The industry has become a diverse industry with a variety of business interests including egg production, broiler production, hatchery and poultry equipment businesses (Rao, 2015). The consumption of chicken has no religious bindings as compared to the case of beef (Hindus) and pork (Muslims) and has an overall acceptable nutritional profile and taste.

The most effective ways to reduce feed costs is to explore alternatives that can reduce feed costs without compromising the nutritional requirements of livestock. Thus, in the course of world clamour for sustained food and nutrition security through organic farming enhancement, the combination of fluted pumpkin (Telfairia occidentalis), bitterleaf (Vernonia amygdalina) and Oha leaf (pterocarpus soyauxii) leaves could be a very good substitute in poultry diets production. Vegetable refuse by definition are those vegetable leftovers either discarded in homesteads or in the market which if allowed to decompose will constitute environmental nuisance and enhances climate change carbon foot print. Often times, VR are thrown out in land-fills were they breakdown anaerobically and produce methane. Methane is about 21 times more potent than carbon dioxide as greenhouse gas.

Vegetable refuse if harnessed properly yields nutrients and energy, vitamins, minerals like phosphorus, calcium, iron, magnesium, zinc and easily digestible fibre (Homestead, 2022). From positive indicators of results from past studies on vegetables wastes, this experiment is therefore aimed to evaluate the performance of finisher broilers placed on graded levels of vegetable wastes as dietary supplement,

MATERIALS AND METHODS
Location of study
This study was conducted at the Poultry unit of the Teaching and Research farm of the Department of agriculture, Alex Ekwueme Federal University Ndufu-Alike Ikwo, Ebonyi State which lies between latitude $06^{0}5'$N and longitude $08^{0}5'$E of the Greenwich meridian and Altitude of 55m. The annual rainfall is between 1000-1500mm.

The vegetation of the area is predominantly derived Savannah and mean annual temperature is about 24^{0}C while relative humidity is between 60-80% (Ogbodo, 2013).

Experimental birds and design

A total of Ninety (90), 4-week old Anak broilers used for the study were obtained from a hatchery farm at Ogun State certified to be of good health and physical stability. They were acclimatized for four (4) days and fed on controlled diet. The birds were raised in a deep litter system whose floor was covered with wood shavings and feed was provided throughout the experimental period. Standard management practices were strictly observed. Thereafter, birds were randomly allocated to five (5) dietary treatments and were replicated three (3) times with each replicate having six (6) birds in a completely randomized design (CRD). Feed and clean drinking water were supplied *ad-libitum* while other routine management practices were observed.

Experimental diets and ration Formulation

The vegetables wastes used for the experiment notably Pumpkin, bitter leaf and Pterocarpus were collected from Ikwo and its environs, dried, crushed in a hammer mill and homogenized before mixing with other basic ingredients. Five (5) treatment diets were formulated such that the homogenized vegetable rejects (VR) was incorporated into the treatment rations at graded levels notably T_1 (VR_0), T_2 ($VR_{1.0}$), T_3 ($VR_{1.5}$), T_4 ($VR_{2.0}$), and T_5 ($VR_{2.5}$) accordingly. The control diet (VR_0) did not contain homogenized vegetable rejects so as to examine the performance of the finisher broilers with respect to the experimental diets. The test ingredient (homogenized vegetable rejects) was subjected to proximate analysis (AOAC, 2006). The broiler birds were weighed at the beginning of the experiment and body weight changes taken thereafter on weekly basis for 28 days. Daily feed intake was determined by obtaining the difference between the quantity of feed given and the quantity leftover. Feed conversion ratio and feed cost/kg live weight were computed accordingly.

Table 1 Ingredients composition of experimental diets fed to broiler birds

Ingredients	VR_0	$VR_{1.0}$	$VR_{1.5}$	$VR_{2.0}$	$VR_{2.5}$
Maize	55	55	55	55	55
Vegetable Rejects	0	1.0	1.50	2.0	2.5
Wheat offal	5.0	5.0	5.0	5.0	5.0
Groundnut cake	20	20	20	20	20
Soyabean meal	10	10	10	10	10
Fish meal	3.0	3.0	3.0	3.0	3.0
Palm kernel cake	3.5	2.5	2.0	1.5	1.0
Sodium Chloride	0.25	0.25	0.25	0.25	0.25
Bone meal	2.50	2.50	2.50	2.50	2.50
L-lysine	0.25	0.25	0.25	0.25	0.25
DL-Methionine	0.25	0.25	0.25	0.25	0.25
Vitamins premix	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100
Calculated Analysis					I
Energy (kcal/kg)	2888.33	2887	2886.35	2886	2885
Crude protein (cp)	21.28	21.84	21.90	21.94	21.98

Table 2: Proximate composition of homogenized vegetable rejects

Fractions	Percentage
Moisture Content	7.50
Crude Protein	16.56
Ether Extract	1.36
Ash	10.57
Crude Fibre	22.57
Carbohydrate (NFE)	41.87
Energy Value (Kcal/Kg)	2213.30

ME= Metabolizable energy calculated; ME (Kcal/kg) =37 × %CP+81 × %E.E+35 × %NFE (Pauzenga, 1985).

Statistical Analysis

Data obtained from the study were subjected to one-way analysis of variance (ANOVA) (Snedecor and Cochran, 1980) using general linear model of SPSS version (SPSS, 2015), while mean value variance showing ($P<0.05$) difference were separated using Duncan's Multiple Range Test as outlined by Onu and Igwemma (2000).

RESULTS AND DISCUSSION

The results shows that there were significant differences (P<0.05) among the treatment means in final body weight, body weight change and average daily weight gain of the birds, however, there were no significant differences (p>0.05) in initial body weight and feed conversion ratio among the treatments (table 3).

Table 3: Performance characteristics of finisher broilers on varying dietary levels of sun-dried vegetable refuse supplementation

Parameters	VR_0	$VR_{1.0}$	$VR_{1.5}$	$VR_{2.0}$	$VR_{2.5}$	SEM
Initial Live weight (g)	1300	1300	1330	1400	1366	29.20
Final weight (g)	2680^c	2720^b	2735^b	2784^a	2780^a	101.7
Av. total weight gain (g)	1350^b	1420^a	1405^a	1384^a	1414^a	52.80
Av. Daily weight gain (g)	48.21^b	50.71^a	50.18^a	49.43^b	50.50^a	2.20
Feed conversion ratio	2.17	2.01	2.15	2.16	2.09	0.13
Total feed intake (g)	2940^b	2856^c	3024^a	2996^b	2968^b	14.00
Av. Daily feed intake (g)	105^c	102^d	108^a	107^{ab}	106^b	4.10
Cost/kg feed (₦)	407.75^a	406.25^a	405.50^{ab}	404.75^b	404.00^b	2.60
Cost of feed/kg weight gain (₦)	880.05^a	817.07^d	872.76b	876.17^b	848.00^c	28.70

a,b,c,d = Means on the same row with different superscripts are significantly (P<0.05) different. SEM= Standard Error of means.

In the present study, initial body weight (28 days of age) was not significantly different among treatments (Table 3) indicating that birds presented uniform body weight at the start of experiment. The highest final body weight of (2784g) was recorded in T_4 ($VR_{2.0}$) while the least body weight of (2680g) was recorded by finisher broilers in $T_{1,}$ while T_2, T_3 and T_5 recorded (2720, 2735 and 2780)g respectively. T_2 and T_3 are statistically similar (P>0.05) while significant differences (P<0.05) existed between T_1 and T_2, T_3, T_4 and T_5 in terms of final body weights respectfully. T_2 recorded the highest daily weight gain (50.71g) followed by T_5, T_3, T_4 and T_1 in that order. Daily weight gain was marginally affected by dietary treatments although the result didn't follow any definite trend. Okerulu et al. (2017) reported that indigenous vegetables like Pterocarpus contain many mineral elements, vitamins, and bioactive compounds which catalyze the growth of animals. Inclusion of vegetable rejects at higher levels reduced weight gain as recorded in T_3, T_4 and T_5 respectively. According to Hossian *et al*. (2013) inclusion of vegetable waste to broiler birds slows down their growth rate but improved meat quality ie aids to maintain broilers requirements. Mustafa & Baurhoo (2017) stated that high vegetable waste inclusion levels in broiler diets resulted to lower nutrient intake and retarded growth. . In addition, high fiber dietary content also causes poor feed efficiency due to nutrient dilution and impairment of absorption and assimilation (Thacker & Petri, 2009).

Average daily feed intake was also marginally influenced (P<0.05) by the dietary VR. Highest feed intake (108g/bird/day) was recorded by T_3 followed by T_4 (107g), T_5 (106g), T_1 (105g) and T_2 (102g) in that order. Feed intake in this study was inversely related to weight gain as T_2 ($VR_{1.0}$) that recorded the highest weight gain didn't follow the same trend in feed intake. The variability in daily feed intake (Table 3) recorded in this study may not be attributed to metabolizable energy content of the treatment diets since the energy contents of all the diets are the same (2887kcal/kg) ie isocaloric but rather attributed to the nutritional variation of the diets (Raza *et al*., 2018). Feed conversion which is a function of nutrient absorption was highest in T_2 (2.01) followed by T_5 (2.09), T_3 (2.15), T_4 (2.16) and T_1 (2.17) in that order. However, no significant difference (P>0.05) existed between the treatment means. From the nutritional view point and convertibility, their exists some inter-relationship between feed conversion ratio and weight gain as finisher birds in T_2 recorded the highest weight gain of 50.71g hence, efficient nutrient absorption promotes increase in weight gain (NRC, 2012). According to Leeson and Summers, (2006) a feed conversion ratio of 2 to 4 is ideal in broiler chicken performance. Feed conversion ratio in this study aligns to the values reported by Adeyemo *et al.*, (2013). Hence birds on VR based diets had better feed utilization than those on control.

The results of the present study are consistent with those reported by Westendorf & Myer (2009), who also observed slow broiler growth rate when vegetable waste was added to the diet. In a similar study, Oghenebrorhie & Oghenesuvwe (2016) obtained comparable final body weight (p>0.05) but worse feed efficiency when 10% of a conventional feed was replaced with vegetable sources. Bhuiyan et al. (2012a, b) fed broilers with diets supplemented with vegetable sources, but did not observe any significant differences in the growth performance. On the economy of production, T_5 promoted the least (N404) followed by T_3 (N406.20), T_4 (N406.75) and T_1 (N407.75) respectively. Cost of feed per kg weight gain was highest in the control diet T_1 (N880.05) and least in T_5 (N848) and statistically different (P<0.05) across the treatment means. Profitability emphasizes the resources used to produce the profit and with least input dissipation, higher rate of return is achieved. Hence, the cost per kilogramme of chicken influences tremendously the cost of the final product.

CONCLUSION AND RECOMMENDATION

The results obtained from this study indicated that VR had a significant effect ($P<0.05$) on growth, average daily feed intake and cost per kilogramme weight gain of finisher broilers. T_2 (1.0 % inclusion) performed better than other levels of inclusion. In view of the above result, VR should be included in the ration of finisher broilers as a supplement at 1.0% level for optimum performance so as to make animal protein available at a reduced cost and maximized profit.

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EFFECT OF FEEDING GRADED LEVELS OF SOYBEAN CHEESE WASTE ON GROWTH PERFORMANCE AND HAEMATOLOGICAL PARAMETERS OF GROWER RABBITS

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ABSTRACT
The effects of feeding grower rabbits with graded levels of soybean cheese waste to determine the growth response and haematology was evaluated in a 42 days feeding trial. A total of 30, composite 10week old rabbits were randomly allotted to the experimental diets in a completely randomized design (CRD) and replicated 3 times having 2 rabbits per replicate. Rabbits were reared in an open-sided mesh hutches and fed with weighed amount of experimental diets and watered at all time. Other standard routine management practices were strictly observed. The diets were formulated to be isocaloric (2700kcal/kg) and isonitrogenous (18% crude protein) with five (5) levels inclusion of soybean cheese waste 0%, 25%, 50%, 75%, and 100% representing T1, T2, T3, T4 and T5 respectively. The result showed significant ($P<0.05$) improvement in the total weight gain (380g/rabbits), average feed intake (63.66g/rabbits) for 75% and 25% SCW inclusion compared with 0% (356.67 and 49.87g/rabbits). Similarly, packed cell volume (41.00%), haemoglobin (13.05g/dL), red blood cell count (6.15 $x10^{12}$) were improved by 50% SCW than 0% SCW (30.50%, 8.70 g/dL and 4.25 $x10^{12}$). White blood cell count increased at 25, 75 and 0% SCW inclusions (9.00, 8.35 and 8.25 x 10^{12}) than rabbits fed diets containing 50% SCW with lower RBC (5.45). Based on the result obtained, up to 100% SCW is recommended for grower rabbit's production without any effect in the performance and physiological responses.
Keywords: *Growth, Haematology, Rabbits, Soybean cheese waste*

INTRODUCTION
Soybean cheese waste (SCW) is an agro-industrial by-product that is found in every part of Nigeria. This is due to the increase in the production of soybeans which has resulted in a concomitant increase in the consumption of soybeans and its products such as soy milk, soy flour, and soy cheese. Soybean cheese waste (residue) is a by-product of soy cheese production (Inuwa *et al.* 2020). It is used in feeding animals such as cattle, sheep, goats, pigs etc. and its readily available and cheap in towns and villages where the cheese is widely produced and consumed. It has the potential for reducing cost of concentrate intake in livestock due to its high nutrient values of soybean and its products (Duwa *et al.*, 2014).

Feeding by-products of crops and food processing waste to livestock has two important advantages; these being to limit dependency of livestock on grains that can be consumed by humans and to eliminate the need for costly waste management programs which has become very important in recent years as the world human population increased, particularly in developed countries (USDA, 2013). Thus, the need for utilizing alternative feed ingredients removed from human and industrial uses have been stressed by several researchers (Fanimo *et al.*, 2007; Nsa *et al.*, 2007).

MATERIALS AND METHODS
Experimental site
This experiment was conducted at the Teaching and Research Farm of Animal Science Department of the Faculty of Agriculture, Nasarawa State University Keffi, Shabu -Lafia Campus.

Source of feed ingredients
The soybean cheese waste (SCW) was sourced from local soybean processors into cheese known as awara within Mangu Local Government Area of Plateau State. The cheese waste (residue) was collected, sun dried for 2-3 days

to reduce the moisture content and also to avoid the growth of mold and rancidity. Other feed ingredients were purchased from feed suppliers in Lafia town, Nasarawa State.

Experimental rabbits and management

Thirty (30) weaned rabbits of the same age and similar live weight were purchased from a reputable rabbits farm in Jos Plateau State and reared in an open- sided mesh rabbit hutches at the rabbits unit of the research and teaching farm of the Nasarawa state university Keffi. They were randomly assigned to a 5 dietary treatments with 3 replicates in each and 2 rabbits per replicate in a Completely Randomized Design (CRD). Each hutch was equipped with feeders and drinkers. Rabbit were fed with weighed amount of the experimental diets and drinking water was supply *ad-libitum* and Other routine management practices were observed.

Proximate analysis of soybean cheese waste

Proximate composition of the experimental test ingredient were determined using the procedure outlined by (1) and the results were presented in Table 1.

Table 1: Proximate Composition of Soybean Cheese Waste (SCW)

Parameters	Values (%)
Dry matter	91.51
Moisture	8.49
Crude protein (CP)	19.33
Crude fibre (CF)	3.86
Ash	3.71
Ether extract	2.18
Nitrogen free extract	62.45
ME kcal/kg	3079.28

NFE=100 - % (CP + CF + EE +ASH+ MOISTURE), c. Dry matter=100% - MOISTURE. (1) d. (10); ME=37 x % CP+81.1 x % EE+35.5 x % NFE.

Experimental diets and composition

Five (5) experimental diets were formulated to provide approximately 2500 kcal/kg and 15% CP for all the experimental groups for the grower rabbits with five (5) levels of inclusion of soybean cheese waste 0%, 25%, 50%, 75%, and 100% representing T1, T2, T3, T4 and T5 respectively. T1 contain 0% SCW and it served as control. Presented in Table 2.

Table 2: Gross composition of experimental grower rabbit's diets/100kg

Ingredients (%)	T1 (0%SCW)	T2 (25%SCW)	T3 (50%SCW)	T4 (75%SCW)	T5 (100%SCW)
Maize	37.00	37.00	37.00	37.00	37.00
Maize offal	12.00	12.00	12.00	12.00	12.00
GNC	5.00	5.00	5.00	5.00	5.00
Rice offal	25.75	25.75	25.75	25.75	25.75
Bone meal	2.00	2.00	2.00	2.00	2.00
Full fat soya	12.00	9.00	6.00	3.00	0.00
SCW*	0.00	3.00	6.00	9.00	12.00
Palm oil	2.00	2.00	2.00	2.00	2.00
Fish meal	3.00	3.00	3.00	3.00	3.00
Common salt	0.25	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
Toxin binder	0.25	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis					
ME Kcal/Kg	2550.49	2568.22	2585.96	2603.70	2621.44
Crude protein (%)	15.82	15.27	15.03	14.78	14.39
Lysine (%)	0.98	0.91	0.84	0.76	0.69
Methionine (%)	0.54	0.53	0.53	0.52	0.51
Ether Extract (%)	8.75	8.28	7.80	7.33	6.35
Crude Fibre (%)	8.01	8.29	8.31	8.43	8.54
Calcium (%)	0.73	0.73	0.72	0.72	0.72
Phosphorus (%)	0.91	0.81	0.84	0.80	0.86

SCW* Soya cheese waste inclusion levels. The vitamin- mineral premix supplied the following per 100kg of diet: vitamin A15,000 I.U, vitamin D3 300,000 I.U. vitamin E 3,000 I.U., vitamin K 2.50mg, vitamin B_1 (thiamin) 200mg, Riboflavin (B_2) 600mg, pyridoxine (B_6), Niacin 40.0mg, vitamin B_{12} 2mg, Pantothenic acid 10.0mg, folic acid 100mg, Biotin 8mg, choline chloride 50mg, anti-oxidant 12.5mg, manganese 96mg, zinc 6mg, Iron 24mg, Copper 0.6mg, Iodine 0.14mg, Selenium 24mg, cobalt 214mg. Using Feedwin software version 1.01

Growth parameters

The growth performance included body weight gain which was computed as the difference between the final weight and the initial weight of the rabbits, feed intake determined as the difference between the amount of feed fed and the leftover. Feed conversion ratio was calculated as the rate of feed intake to live weight gain/day from the data obtained.

Haematological parameters

At the end of the experiment, sample bottles were used to collect blood samples from two rabbits per treatment through the ear veins. The blood samples were collected in bottles containing Ethylene Diaminetetra-acetic Acid (EDTA) as an anti-coagulant for analysis of hematological indices: Packed Cell Volume (PCV). Hemoglobin Concentration (Hb), Red Blood Cell (RBC), White Blood Cell (WBC). Mean corpuscular haemoglobin (MCH), Mean corpuscular haemoglobin concentration (MCHC), MCV = Mean corpuscular volume.

Statistical analysis

Data collected were subjected to one way analysis of variance (ANOVA) using (SPSS) Model 22. Significantly different means were separated using Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

Table 3 shows significant ($P<0.05$) improvement in the total weight gain (380g/rabbits), average feed intake (63.66g/rabbits) for 75% and 25% SCW inclusion compared with 0% (356.67 and 49.87g/rabbits) but statistically similar for T1, T4 and T5 respectively. Feed conversion ratio (12.73 and 11.67) were significantly ($P<0.05$) higher for 25 and 50% SCW. This indicated poor conversion of feed to flesh. However, 0, 75 and 100% had lower FCR which indicate better conversion of feed to flesh. In the same vain, packed cell volume (41.00%), haemoglobin (13.05g/dL), red blood cell (6.15 $x10^{12}$) were improved by 50% SCW compared with 0% SCW (30.50%, 8.70 g/dL and 4.25 $x10^{12}$). Similarly, white blood cell increased at 25, 75 and 0% SCW inclusions (9.00, 8.35 and 8.25 $x\ 10^{12}$) but did not show difference with 100% included SCW (T5). Rabbits fed diets containing 50% SCW had lower RBC (5.45) but did not cause any signs of diseases throughout the period of the experiment. The improvement in the total body weight in this study agreed with Iyeghe-Erakpotobor *et al.* (2006) who fed soybean cheese waste/maize and brachiaria hay to weaner rabbits and observed significant increase in body weight gain, average body weight gain and lower feed conversion ratio. The increase in the level of packed cell volume, haemoglobin, and red blood cell for rabbits fed 50% soybean cheese waste. Generally, the soybean cheese waste-based diets had better values for these parameters compared to the control. The red blood cells values indicates that rabbits have normocytic and normochromic red cells (Aderemi and Wuraola, 2010), thus, explaining that feeding soybean cheese waste up to 100% inclusion does not affect the utilization of iron. The lower value of white blood cells in 50% indicates a fall in the production of defensive mechanism to combat infection when it occurs. Madubuike and Ekenyem (2006) indicated that haematological characteristics of livestock suggest their physiological disposition to the plane of nutrition. Since all the haematological parameters fall within the normal ranges for rabbits, it then implies that the different treatment diets fed the rabbits were balanced in their formation to promote their performance and maintained the normal physiological profile of the rabbits.

Table 3: Effect of graded levels soybean cheese waste (SCW) on growth performance and haematology of grower rabbits

	Dietary levels of SCW (%)						
Parameters	**$T1_{(0)}$**	**$T2_{(25)}$**	**$T3_{(50)}$**	**$T4_{(75)}$**	**$T5_{(100)}$**	**SEM**	**LOS**
Growth indices							
IW (g/rabbit)	1160.00	1206.67	1206.67	1203.33	1203.33	45.89	NS
FW (g/rabbit)	1516.67	1450.00	1393.33	1583.33	1493.33	46.27	NS
TWG (g/rabbit)	356.67^{a}	210.00^{b}	186.67^{b}	380.00^{a}	290.00^{ab}	25.35	*
Av. FI	49.87^{b}	63.66^{a}	51.85^{b}	55.46^{ab}	52.03^{b}	1.69	*
FCR	5.87^{b}	12.73^{a}	11.67^{a}	6.13^{b}	7.54^{b}	0.99	*
Haematological indices							
Packed cell volume (%)	30.50^{c}	36.50^{ab}	41.00^{a}	35.00^{b}	34.00^{b}	1.74	*
Haemoglobin (g/dl)	8.70^{c}	11.85^{ab}	13.05^{a}	11.55^{b}	11.20^{b}	0.61	*
Red blood cell ($x10^{12}$)	4.25^{c}	5.00^{ab}	6.15^{a}	5.10^{ab}	4.63^{bc}	0.30	*
White blood cell ($x10^{9}$)	8.25^{a}	9.00^{a}	5.45^{b}	8.35^{a}	7.80^{ab}	0.48	*
MCH (pg)	22.55	23.50	22.85	22.60	22.50	0.48	NS
MCHC (g/dl)	32.55	35.00	32.00	32.50	30.80	0.67	NS
MCV (fl)	73.50	75.00	72.00	69.00	71.00	1.37	NS

SEM= Standard error means, LOS= Level of significant, a, b, c, = Means on the same row bearing different superscript differ significantly (P<0.05); NS= No significant (P>0.05), SCW= soybean cheese waste, IW= initial weight; FW= final weight; TWG= total weight gain; Av.FI = average feed intake; FCR= feed conversion ratio; MCH = Mean corpuscular haemoglobin, MCHC = Mean corpuscular haemoglobin concentration, MCV = Mean corpuscular volume.

CONCLUSION AND RECOMMENDATION

Inclusion of soya bean cheese waste in the diet of grower rabbits had improved growth performance by 75% and also increases most of the haematological indices up to 100%. It is therefore recommended for the grower rabbit's production without any deleterious effect.

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EVALUTION OF HAEMATOLOGICAL AND GROWTH PERFORMANCE OF WISTER RATS FED CORN MEAL COMBINED WITH ANTIBIOTICS

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ABSTRACT

This study aimed to determine the effects of antibiotics inclution in corn meal on haematological and growth performance of Wister rats. Thirty (30) Male Wistar strain of albino rats, divided into five groups (A-E) of six (6) each arranged in a Complete Randomised Design. Rats were managed on a deep litter system for 6 weeks. Data on body weight, feed intake, feed conversion ratio and blood parameters were collected. On weight gained, there was no significant difference (P = 0.05) in groups A, B and E which were significantly (P<0.05) higher compared to groups C and D rats. For feed intake, sample A, D and E were similar no significant different compared to B and C. In protein intake, groups A, C and E were similar with no significant different compared to B and D that were significantly different. In NPR, groups A, C and D were similar in which there were no significant different in them compared to groups B and E. In PER, sample A, B, C and D were similar in which there were no significant different in them compared while sample E was significant different only. In FER, sample B, C, D and E were similar in which there were no significant different in them compared to group A only. In SGR, sample B, D and E were similar in which there were no significant different in them compared to sample A and C. In PR, sample A, B, D and E were similar in which there was no significant different in them compared to group C only. The PCV of the rats were similar in which sample A, C and D were no significant different in them compared to sample B and E that were significantly different. The PCV values fell within the normal range of 25% – 45%. In hemoglobin, sample A, B and D were similar in which there was no significant different in them compared to groups C and E that were significantly different. However, the total RBC count of the rats was similar in which there was no significant different in sample A, D and E compared to sample B and C that were significantly different. the total WBC count of the rats were similar in which there was no significant different in sample B, C, D and E compared to sample A that was significantly different (P = 0.05). The platelet count of the rats were similar in which there was no significant different in all the samples. It can be concluded that supplementation of corn powder with different antibiotics improved growth performance and haematological characters in wister rats.

Keywords: *Corn meal, weight gained, blood parameter, blood serum, biochemical indices*

INTRODUCTION

Nutrition has been recognized as a major constraint to livestock production in Nigeria and elsewhere (Okai and Boateng, 2007 and Yusuf *et al*., 2008). Research has shown that feed cost accounts for 70-80% of total production (Sola-Ojo *et al*., 2011) and protein is likely to be the first limiting factor in poultry diets at the level of small scale farmers. The feed cost in Nigeria, just as any other developing countries of the world, is quite expensive, and often beyond the reach of ordinary farmer. The end of the 20th century was marked by drastic increase in the incidence of protein energy malnutrition, chemical hazards and other safety issues (Moterjemi and Lelieveld, 2013).
The use of laboratory rats (*Rattus norvegicus*) in research has increased steadily as they are preferred because of their short life cycles, inexpensive cost to purchase, easy maintenance in limited space (Neg, 2008) and availablity of a large database of their characteristics that are useful in interpreting relevant animal data for humans. The rats particularly the inbred strains are now more widely used as laboratory model in the understanding and studying of diseases (Ihedioha and Okafor, 2004; and Smith *et al*., 2004). In this research, abnormal treatment-related values could represent changes pertaining to the effects of the treatments such as the toxicity's effects, which could be detected by alterations in a series of in vivo analysed parameters (Ihedioha and Okafor, 2004). Among these parameters are haematology data and are of great importance in determining such effects. This is because

blood plays a major role in the body's transport system and excretion of substances of almost all the body's metabolic processes, and any deviations from normal are detectable in the blood profile (Ihedioha and Okafor, 2004) One way of evaluating the haematologic profile is by Full Blood Count (FBC) otherwise called Complete Blood Count (CBC).

It also provides information about the immune system through the evaluation of the WBC counts especially along with differential counts (George-Gay and Parker, 2003). Thus, CBC is one of the most frequently requested tests in clinical medicine with multiple indications such as anaemia, cancer, infection as well as monitoring for side effects of drugs causing blood dyscrasias (George-Gay and Parker, 2003; Graham, 2003) of all the rat models, Sprague Dawley (SD) rats are the most widely used research models in all aspects of biomedical (Ihedioha and Okafor, 2004). In evaluating the biological effect of some food on rat organs (small intestine, pancreas, liver and heart), Smith *et al*., 2004 observed no significant difference in the organ weight of the rats fed the test diets as compared with cerelac- a commercial weaning diet. Rats fed on extruded weaning foods based on peanut, maize and soybean were observed by Smith *et al*., 2004 to have between 60-100-fold increases in mean weight gain over the control. It was also reported that haemotological data of test animals showed normal values for white blood cell count, red blood cell count, haemoglobin level and packed cell volume for all the weaning food studied except the control.

MATERIALS AND METHODS

Description of Study Area

The study was carried out in Ibarapa central local government area, which has its head quarters in the town of Igboora, covers about 440km^2 of savannah zone to the west of Ibadan, the Ogun and Oyan rivers from eastern and western boundaries respectively. It is between latitude 7'53^0 and longitude 3'08^0 with the population of 102,979 according to 2006 census (Sanusi, 2011).

Experimental animals

Thirty (30) Male Wistar strain of albino rats, divided into five groups (A-E) of six (6) rats each per group were used for the studies. The average weights of the rats were between 150 to 200g. The rats were housed individually in stainless-steel metabolic cages. The rats were allowed to acclimatize with the environment and feeding trial was done for four weeks with each group receiving graded levels of corn meal and bone meal mixed with antibiotics.

The antibiotics used include, Penicillins, Cephalosporins, Cloraphenicol and Gentamycine.

Experimental diets and Treatment

Rats were divided into five (5) groups and labeled as follows, A with Penicillins, B with Cephalosporins, C with Cloraphenicol, D with Gentamycine and Control = E with no antibiotics. The rats were fed for 30 days

Growth performance

At the onset of the experiment, initial body weights of the rats were recorded. Feed intake (FI) and body weight (BW) were measured weekly. Mortality was recorded as it occurred. Weight gain, average daily weight gain, and feed conversion ratio were calculated. The weight gain was calculated as the difference between the final weights and the initial weights. FI was determined as the difference between the amount of feed offered and refusals. Feed conversion ratio (kg feed/kg gain) was calculated by dividing FI by BW gain.

The growth performance was evaluated in terms of feed intake (FI), weight gain (%), specific growth rate (SGR) and feed efficiency ratio (FER).

Weight gain (%) = (final weight - initial weight) /initial weight ×100

SGR = 100 (loge average final weight x loge average initial weight) /number of days z

FER = weight gain (g)/feed intake (g)

Haematological parameters

Blood collection was carried out at the end of the experiment (6th week). Five (5) rats were selected at random from each of the treatments and bled via the vein using sterile needles and syringes. Two (2.0) ml of blood was collected into each sterilised bottles containing EDTA as anticoagulant for haematological analysis. The packed cell volume (PCV), red blood cell (RBC) count, white blood cell (WBC) count, Platelet and haemoglobin (Hb) concentrations were measured using Mindray BC 2800, an automated system for the determination of haematological parameters.

Statistical analysis

The data were analyzed using one way ANOVA and expressed as mean ± SEM. The significant differences between means were determined using Duncan's multiple range comparison tests. The level of significance was set at 5%. All analyses were performed using statistical software package SPSS version 16.

RESULTS AND DISCUSSION

Weight gained, food intake, protein intake and feed conversion ratio

The results of effects of treatment on growth performance of Wister rats were presented in Table 1. In weight gained, there was no significant difference ($P = 0.05$) in between groups A, B and E which were significantly ($p<0.05$) higher compared to groups C and D. In feed intake, groups A, D and E were similar with no significant different compared to groups B and C. In protein intake, groups A, C and E were not significant compared to groups B and D that were significantly different. In NPR, groups A, C and D were not significant compared to groups B and E. In PER, groups A, B, C and D were not significant while group E was significant. In FER, sample B, C, D and E were not significant compared to sample A. In SGR, groups B, D and E were not significant compared to group A and C. In PR, groups A, B, D and E were similar and significantly higher compared to group C. The results obtained were similar to the work of Tokofai *et al*., (2020) in which there was variation in weight gained, food intake, protein intake and feed conversion ratio.

Table 1. Effect of corn meal on the performance of the wister rats

Parameters	Sample				
	A	B	C	D	E
Weight Gained (g)	51.73 ± 2.15^{a}	55.21 ± 1.26^{a}	49.97 ± 2.33^{b}	49.65 ± 1.95^{b}	53.07 ± 2.03^{a}
Food Intake (g)	709.00^{c}	854.00^{b}	897.00^{b}	843.00^{c}	899.00^{c}
Protein Intake (g)	18.34^{b}	19.17^{a}	19.57^{b}	18.77^{c}	19.96^{b}
NPR	1.22^{b}	1.80^{a}	1.23^{b}	1.13^{b}	1.14^{c}
PER	2.22^{b}	2.23^{b}	1.99^{b}	2.20^{b}	1.54^{a}
FER	0.07^{b}	0.06^{a}	0.06^{a}	0.06^{a}	0.06^{a}
SGR	1.35^{c}	1.98^{b}	1.47^{a}	1.33^{b}	1.69^{b}
PR	45.24^{b}	43.14^{b}	41.22^{a}	43.57^{b}	49.63^{b}

^{abc} Means with different superscripts on the same row differ significantly ($P < 0.05$) while a, b and c with the same superscripts on the same row are not differ significantly ($P < 0.05$).

NPR = Net protein utilization, PER = Protein efficiency ratio, FER = Feed efficacy ratio, SGR = Specific growth rate, PR = Protein ratio, Weight gained % = final weight - Initial weight/ initial weight X 100, Specific growth rate (SGR) = 100(Log_eaverage final weight X Log_eaverage initial weight) /number of days, FER = Weight gained (g) / feed intake (g)
A = bone meal combined with Penicillins., B = bone meal combined with Cephalosporins.
C = bone meal combined with Cloraphenicol., D = bone meal combined with Gentamycine.
E = control group animals and given normal rat cerelac only.
Table 2 shows the haematological characters of the various treatments. The PCV of the rats were similar and samples A, C and D were not significant compared to sample B and E that were significantly different. The PCV values fell within the normal range of 25% – 45%. In hemoglobin, samples A, B and D were not significant compared to samples C and E that were significantly different. However, the total RBC count of the rats was similar and was not significant samples A, D and E compared to samples B and C that were significantly different. The total WBC count of the rats were not significant in samples B, C, D and E compared to sample A that was significantly different ($P = 0.05$). The platelet count of the rats was not significant different in all the samples.

Table 2. Haematology repormance of corn meal on blood characters of wister rat

Parameters	Samples				
	A	B	C	D	E
PCV (%)	34.9^{a}	33.5^{b}	32.4^{a}	35.7^{a}	35.3^{b}
Hemoglobin (g/dl)	11.0^{a}	10.7^{a}	10.5^{b}	11.0^{a}	11.9^{c}
RBC (x10^{6uL})	5.38^{a}	5.26^{b}	5.20^{b}	5.42^{a}	5.49^{a}
WBC (x10^{3u}L)	3050^{b}	4250^{a}	4150^{a}	4650^{a}	3940^{a}
Platelet	166000^{b}	159000^{b}	1730600^{b}	165000^{b}	164000^{b}

^{abc}Means with different superscripts on the same row differ significantly ($P < 0.05$). PCV = Packed cell volume, RBC = Red blood cell, WBC = White blood cell

DISCUSSION

Body weight, feed intake and feed conversion ratio

From this study, it could be clearly shown that incorporation of corn meal with different antibiotics in the wister rat diet had affected the growth performance and haematological and characteristics of the blood. The performance of the rats in the present study shows that the final weight gain and feed conversion ratio of the rats were significantly different. The rats fed with corn meal had better weight gain and feed conversion ratio. The result is in line with the findings of (Yusuf *et al*., 2008) who reported improved growth performance of rats fed with bitter leaf. The improvement in weight gain observed in the treated group resulted in a lower FCR. (Olobatoke and Oloniruha, 2009) reported that inclusion of corn meal powder in rat diets significantly improved FCR.

Haematological variable

In the study, there was no influence of the dietary treatment on haematological indices among the treatments, except for PCV and WBC. On the other side, there was a marginal increase in RBC levels of rats fed corn meal and this shows that corn meal powder may have a possible potential to stimulate erythropoietin release from the kidneys, which is the humoral regulator of RBC production. According to Maxwell *et al*., (1990), blood parameters are important in assessing the quality and suitability of feed ingredients for farm animals. It's also reported that blood parameters are the major indices of the physiological, pathological, and, when compared to normal values, nutritional status of an organism. Changes in the constituent compounds of blood could be used to interpret the metabolic stage of an animal as well as the quality of the feed (Attia *et al*., 2017; Attia *et al*., 2018; Attia *et al*., 2019). The higher PCV and WBCs in rats offered corn meal are in agreement with earlier findings of Owen and Amakiri (2011) who showed that, with the exception of WBC, all other haematological indices measured were influenced by increasing levels of corn powder. The numerical differences observed in the PCV, Hb, RBC, and WBC of rats fed suggest that the feed were better utilised and assimilated into the blood stream of the rats (Onu, 2010).

CONCLUSION

Considering the effects of different levels of corn meal on weight gain, food intake and feed gain ratio of the rats, it appears that the corn meal showed optimum effect on the improvement of growth performance and physiological responses in rats. It can therefore be recommended for wister rat as meal for growth performance, although further experiments are recommended for further findings.

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EFFECTS OF GENOTYPE, VARYING DIETARY ENERGY AND PROTEIN ON GROWTH PERFORMANCE OF LOCAL AND IMPROVED NIGERIAN INDIGENOUS GUINEA FOWL

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ABSTRACT
Growth in animal is determined by a complex variety of factors which can be reduced to three main factors – the animal's gene pool, the nutrients with which it is supplied, and its environment. This 10-week feeding trial was carried out to evaluate the effect of genotype, dietary energy, and protein inclusion on growth (body weight) of local and improved Nigerian indigenous guinea fowl keets. A total of two hundred and sixteen (216) brooded unsexed guinea fowls: 108 locals and 108 crossbreds were assigned to nine (9) experimental diets (T1, T2, T3, T4, T5, T6, T7, T8 and T9). A 2x3x3 factorial layout (genotype: local and improved; crude protein: 26, 24 and 22% CP and metabolizable energy ME: 2650, 2750 and 2850.00 Kcal/kg) fitted in a completely randomized design was adopted for the study. Data obtained were subjected to GLM procedure to determine the fixed and interaction effects on growth performanc. The improved keets showed superior growth performance (P<0.05) compared to their local counterparts. Variations in growth performance (P<0.01) were also observed due to crude protein and energy. Keets fed diet containing 2,650 and 2,750 Kcal/kg showed similarity in performance and had higher body weights. With respect to protein, inclusion at 24% CP had the best performance. For interaction, keets fed 24% CP with 2,650 Kcal/kg performed best. Therefore, it is recommended that 24% CP and 2,650 Kcal/kg inclusion levels could lead to good growth of keets.
Keywords: *Dietary, Energy, Protein, performance, guinea fowl*

INTRODUCTION
Guinea fowl production in Nigeria is gradually gaining prominence (Obike, 2014). This witnessed popularity is because of their relished meat and egg, scavenging ability, and resistance to common chicken diseases (Naandam & Issah, 2012) as well as their ability to utilize marginal areas. The popularity may however be limited or short lived if deliberate efforts are not directed towards understanding their optimum nutritional requirements, eggs, and growth performance. In communities where guinea fowls are fondly raised, they are allowed to scavenge freely; this practice will not reveal the true worth of the birds neither will it promote commercialization. However, like with chicken production, growth and nutritional development will accelerate production and commercialization of guinea fowls. Protein and energy play critical roles in the development of animals. They are needed to maintain health, growth, and production (Ihiwe et al., 2018). While energy controls feed consumption, protein serves as building blocks for cells and aid repairs and maintenance of body cells and tissues. The utilization of commercial feed on performance of guinea fowls have been investigated, however, there is a dearth of

information on formulated feed that utilized locally accessed ingredients. This study, therefore, evaluated the performance of local and improved guinea fowl keets fed formulated diet with three levels of proteins and energy.

MATERIALS AND METHODS

The experiment was carried out at the Guinea Fowl Improvement Unit of the Teaching and Research Farm, Landmark University, Omu-Aran, Kwara State, Nigeria. The Unit is co-managed by the Federal University of Agriculture, Abeokuta, Landmark University and Nasarawa State University, Keffi, Shabu-Lafia Campus to facilitate the implementation of the 2019 TETFUND National Research Grant for guinea fowl improvement in Nigeria. The farm lies on latitude 8.9ºN and longitude 50.61ºE within the guinea savannah zone of North Central Nigeria. A total of two hundred and sixteen (216) brooded unsexed guinea fowls: 108 locals and 108 crossbreds (Local x Exotic) were assigned to nine (9) experimental diets (T1, T2, T3, T4, T5, T6, T7, T8, T9). A 2x3x3 factorial layout (genotype: local and improved; crude protein: 26, 24 and 22% CP and metabolizable energy ME: 2650, 2750 and 2850.00 Kcal/kg) fitted in a completely randomized design was adopted for the study. Body weight (grams) and feed intake were observed throughout the study period using sensitive weighing scales. Data obtained were subjected to general linear model (GLM) procedure to determine fixed and interaction effects using IBM-SPSS (2020). Significant differences were separated using the least significant difference (LSD) method.

RESULTS AND DISCUSSION

Table 1 shows the composition of the feed for the keep phase.

Table 1: Feed Composition for Keet Phase

Ingredients	T1	T2	T3	T4	T5	T6	T7	T8	T9
Maize	38.00	43.00	46.00	41.00	47.50	50.00	41.00	46.00	55.00
SBM	37.00	37.00	46.00	30.00	38.00	39.00	25.00	30.00	40.00
GNC	14.00	14.00	0.00	14.00	6.00	6.00	13.50	10.00	0.00
CB	1.00	0.00	0.00	2.00	0.00	0.00	7.50	6.00	1.00
WO	6.00	2.00	0.00	9.00	4.50	0.50	9.00	4.00	0.00
FM	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00
V/Oil	0.00	0.00	1.00	0.00	0.00	0.50	0.00	0.00	0.00
Bonemeal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Limestone	0.80	0.80	0.80	0.8.0	0.80	0.80	0.80	0.80	0.80
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Enzyme	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Vit. E.	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
ME (Kcal/kg)	2650.00	2750.00	2850.00	2650..00	2750.00	2850.00	2650.00	2750.00	2850.00
CP %	26.00	26.00	26.00	24.00	24.00	24.00	22.00	22.00	22.00

T1 – T9 = Treatment 1-9; SBM =Soya bean meal; GNC = Groundnut cake; CB =; FM = Fish Meal, WO = Wheat offals V/Oil = vegetable oil; ME = Metabolizable Energy; CP = Crude Protein.

Table 2 shows the effect of genotype on the growth performance of keets. From the result obtained, the growth performance of the local and crossbred keets significantly differed (P<0.05) with higher values recorded for the latter. The overall or combined records also showed significant (P<0.05) improvement in growth performance from week 1 to week 10.

Table 2: Effect of Genotype on weekly body weight of Crossed and Local Guinea Fowls

Week	Crossed	Local	Overall
1	63.64 ± 0.77^a	57.23 ± 0.77^b	60.44 ± 0.54^q
2	126.99 ± 0.77^a	120.17 ± 0.77^b	123.58 ± 0.54^r
3	182.61 ± 0.77^a	176.01 ± 0.77^b	179.31 ± 0.54^s
4	244.94 ± 0.77^a	238.02 ± 0.77^b	241.48 ± 0.54^t
5	315.40 ± 0.77^a	302.93 ± 0.77^b	309.16 ± 0.54^u
6	392.07 ± 0.77^a	373.71 ± 0.77^b	382.89 ± 0.54^v
7	481.84 ± 0.77^a	457.89 ± 0.77^b	469.87 ± 0.54^w
8	574.99 ± 0.77^a	546.87 ± 0.77^b	560.93 ± 0.54^x
9	639.78 ± 0.77^a	615.31 ± 0.77^b	627.55 ± 0.54^y
10	693.51 ± 0.77^a	664.94 ± 0.77^b	679.23 ± 0.54^z

$^{a\,b}$ Means bearing different superscripts in a row differ significantly at P<0.05

$^{q,\,r,\,s,\,t,\,u,\,v,\,w,\,x,\,y,\,z}$ Means with different superscripts in a column differ significantly at P<0.05

Growth in animals represents increased in size and or mass. It is influenced by the genetic makeup and the environment of the animal (Pell, 1994). The observed superiority of the improved keets to their local counterparts could be attributed to the influence of better genetic traits acquired from the crossing of their parents with an exotic breed. This is consistent with the findings of Kgwatalala et al. (2020) where crossbreeding was found to be effective in improving the growth performance of guinea fowl.

The effect of varying protein on growth performance of guinea fowls keets is presented in Table 3. The result showed significant (P<0.01) effect on growth rate. Superior growth was recorded in keets fed diet containing 24% CP.

Table 3: Effect of Protein on Growth rate of Crossed and Local Guinea Fowls

Week	P1 (26)	P2 (24)	P3 (22)
1	62.00 ± 0.94^{b}	64.83 ± 0.94^{a}	54.47 ± 0.94^{b}
2	122.07 ± 0.94^{b}	126.68 ± 0.94^{a}	121.99 ± 0.94^{b}
3	180.14 ± 0.94^{b}	182.08 ± 0.94^{a}	175.71 ± 0.94^{b}
4	239.99 ± 0.94^{b}	246.24 ± 0.94^{a}	238.22 ± 0.94^{b}
5	306.56 ± 0.94^{b}	311.72 ± 0.94^{a}	309.21 ± 0.94^{b}
6	377.50 ± 0.94^{b}	385.65 ± 0.94^{a}	385.51 ± 0.94^{b}
7	460.69 ± 0.94^{b}	477.08 ± 0.94^{a}	471.83 ± 0.94^{b}
8	550.61 ± 0.94^{b}	568.14 ± 0.94^{a}	654.04 ± 0.94^{b}
9	625.04 ± 0.94^{b}	630.49 ± 0.94^{a}	627.11 ± 0.94^{b}
10	676.04 ± 0.94^{b}	681.78 ± 0.94^{a}	679.86 ± 0.94^{b}
Overall	**360.06 ± 0.29^{b}**	**367.47 ± 0.29^{a}**	**362.79 ± 0.29^{b}**

[a b] Means bearing different superscripts in a row differ significantly at P<0.01).

Feed intake decreased as protein inclusion increased from 24% CP to 26% CP. The observed decrease in feed intake as protein inclusion increases shows that the keets had satisfied their protein requirement at 24% CP inclusion level. Inclusion at 26% CP represents waste of nitrogen and ammonia (Liu et al., 2021) as well as financial resources, which is related to the findings of Batkowska et al. (2021). The present observation agrees with the report of Amoah et al. (2018) whose recommended 24% CP as optimum protein inclusion level in Ghanian guinea fowl. Similarly, an earlier study by Nahashon et al. (2005) reported that semi domesticated guinea fowl keets were found to perform best on 20-24% CP diet. However, this could be reduced to 18% by eight weeks of life.

Table 4 presents the effect of varying energy on the growth rate of guinea fowls keets. Keets fed diet containing E1 (2,650) and E2 (2,750) had higher body weight for week 1, 2, 3 and 4 than E3 (2850) respectively. Similarly, Week 6, followed the same trend with week 1, 2, 3 and 4 respectively. At week 7, keets fed E2 (2750) had higher growth compared E1 and E3 which were similar. At week 8, growth rate improved consistently as the energy inclusion increased in the diet. At week 9 and 10, keets fed E1 (2,650) had higher growth rate than those on E2 and E3. E2 had a lower growth rate compared with E3. The overall growth rate was higher for keets fed E1 and E2 compared with E3. The improved growth rate of keets fed diet E1 (2,650) and E2 (2750) is contrary to Amoah et al. (2018) who reported high 12.5 MJ ME /kg (2,985.63 kcal/kg ME).

Table 4: Effect of Energy (Kcal/kg ME) on Growth Performance of Crossed and Local Guinea Fowls

Week	E1 (2,650)	E2 (2,750)	E3 (2,850)
1	61.47 ± 0.94^{a}	61.04 ± 0.94^{a}	58.79 ± 0.94^{b}
2	123.89 ± 0.94^{a}	124.64 ± 0.94^{a}	122.21 ± 0.94^{b}
3	179.27 ± 0.94^{a}	180.73 ± 0.94^{a}	177.92 ± 0.94^{b}
4	241.64 ± 0.94^{a}	242.57 ± 0.94^{a}	240.24 ± 0.94^{b}
5	308.65 ± 0.94^{b}	310.36 ± 0.94^{a}	308.47 ± 0.94^{b}
6	382.97 ± 0.94^{a}	383.99 ± 0.94^{a}	381.71 ± 0.94^{b}
7	468.71 ± 0.94^{b}	471.17 ± 0.94^{a}	469.73 ± 0.94^{b}
8	559.39 ± 0.94^{b}	560.96 ± 0.94^{b}	562.44 ± 0.94^{a}
9	630.36 ± 0.94^{a}	625.19 ± 0.94^{c}	627.08 ± 0.94^{b}
10	681.47 ± 0.94^{a}	677.21 ± 0.94^{c}	679.00 ± 0.94^{b}
Overall	**363.78 ± 0.29^{a}**	**363.79 ± 0.29^{a}**	**362.76 ± 0.29^{b}**

[abc] Means bearing different superscripts in a row differ significantly at P<0.0

Superior average body weight of 372.89±0.51g was recorded for keets fed the energy and protein levels combination of P2 (24% CP) and E1 (2,650 kcal/kg) (Table 5). However, the least body weight of 358.37±0.51g was recorded against the energy and protein levels combination of P1 (22% CP) and E1 (2,650 kcal/kgME. These are in consonance with those of Nahashon et al. (2006) and Odukwe et al. (2017) who reported decrease in feed intake with increase in energy inclusion, which could affect growth performance. Generally, animals feed to meet their ME requirement. The rate of feed consumption decreases when birds are fed a high energy diet due to heat increment, which does not encourage high feed intake but rather encourage high water intake.

Table 5: Effect of Protein (and Energy Interaction on Growth Performance of Crossed and Local Guinea Fowls

Protein (%)	Energy (Kcal/kg ME)	Body weight (Average for ten weeks)
P1 (22)	E1 (2,650)	358.37±0.51^{b}
	E2 (2,750)	362.12±0.51^{a}
	E3 (2,850)	359.71±0.51^{ab}
P2 (24)	E1 (2,650)	372.89±0.51^{a}
	E2 (2,750)	366.48±0.51^{b}
	E3 (2,850)	363.05±0.51^{c}
P3 (26)	E1 (2,650)	360.11±0.51^{c}
	E2 (2,750)	362.77±0.51^{b}
	E3 (2,850)	365.53±0.51^{a}

^{abc} Means bearing different superscripts in a column differ significantly at $P<0.05$

CONCLUSION

Genotype, variation of crude protein and energy in the diet of guinea fowl keets significantly affected their growth performance. Result of interaction showed that, inclusion at P2 (24% CP) with E1 (2650) had superior performance. Hence, 24% CP with up to 2750kcal/kg ME is recommended for better growth performance.

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EFFECTS OF FARMERS-HERDERS CONFLICTS ON ARABLE CROP PRODUCTION IN OKE-OGUN AREA OF OYO STATE, NIGERIA

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ABSTRACT
This study assessed the effects of farmers-herders conflicts on arable crops production in Oke-Ogun area of Oyo State, Nigeria. Farmers and herders which are the largest agricultural land-users need land to carry out their activities. However, the conflicts between the two major agricultural land users over the use of existing land is not a new thing but it is an age long issue that has been existing in different parts of Nigeria. Multistage sampling procedure was used to select 160 respondents for the study. Data were collected using interview guide to elicit information on Socio-economic characteristics, causes of conflict sand the effects of the conflicts on the arable crop production. The results showed that poisoning of animals (88.13%) and tribalism (84.38%) were the major causes of the conflicts in the area. The study concluded that the effects of famers-herders conflicts was unfavorable on their crop production in the study area. Based on the findings, it was recommended that government should provide drinkable water for the populace, so as to reduce competition for water between the farmers and the Fulani cattle, since scarcity of water was indicated as one of the causes of the conflicts in study area.
Keywords: *Herders, Arable crops, Conflicts.*

INTRODUCTION
All human activities whether in urban or rural area are dependent on land. However, agricultural land must be rich in nutrient and water which makes it suitable for agricultural production activities. Farmers and herders which are the largest agricultural land-user needs land to carry out their activities. However, the conflicts between the two major agricultural land users over the use of existing land is not a new thing but it's an age long thing that has been existing in different parts of Nigeria. Due to the economic importance of land to the group, it is therefore not surprising that unhealthy competition will exist between the two groups on the use, control, ownership and acquisition of land. Nigeria which is one of the African countries is not immune to these conflicts. Although the two of them have co-existed for over a long period of time, the crisis between farmers and herders over competition on who owns and control economically viable lands in the country is taking a more drastic dimension. This is because more sophisticated arms are used by herders leading to the death of many farmers, the perceived lack of political will on the part of the government at the federal level to manage this conflict, destruction of properties and the crisis is gradually taking an ethnic dimension against the Fulani's who are generally seen as herders (Cotula, *et.al*,2004). Farmers-herders conflict in the 21st century in the use of agricultural land are becoming intense because of a number of factors such as climatic change which is pushing herders southward in search of water and grasses, increased human population (Fasona and Omojola,2005). Many researchers had workedon farmers-herdsmen conflicts but this study will work on how farmers-herdsmen conflicts have affected the arable crops production in the study area. Moreover, this aspect has not been given adequate attentions in the existing literature. The specific objectives of the study were to: identify the socio-economic characteristics of the respondents in the study area, identify the causes of farmers-herders' conflicts and asses the effects of farmers-herdsmen conflict on arable crops production.

METHODOLOGY
The study area is Oke Ogun area of Oyo state. Okeogun is one of the materially richest parts of Oyo state. It lies within latitude $7^0$70'N and longitude $2^0$60' EThe target population comprised of all the arable crop farmers in Oke Ogun Area of Oyo State. Multistage Sampling procedure was used to select 160 respondents for the study;. According to Oyo State Agricultural Development Programme (OYSADEP) administrative System, there are 24 functional Cells in the chosen Local governments, 20% of the cells was randomly chosen to give 5 cells. There

are 1605 arable crops farmers in the Extension agents register covering the 5 cells. 10% of the registered farmers were randomly chosen to give 160 respondents for the study.

RESULTS AND DISCUSSION

Socioeconomic characteristics of arable crop farmers

The result of the Socio-economic characteristics of the respondents is presented in Table 1. The results show the mean age of the respondents was 47 years. This implies that majority of the respondents were in their productive age. This is in line with Brown *et. al.*, (2019) that age may influence land use decisions. Majority (65.63%) of the respondents were married while 33.37% of them were single. The educational distribution of the respondents revealed that 21.88% of the respondents had no formal education while 60.00%, 15.63% and 2.50% of the them had primary education, secondary education and tertiary education respectively. This implies that majority of the respondents had one form of education or the other.

Table 1: Socio-economic characteristics of arable crop farmers in the study area

Socio-economic characteristics	Frequency	Percentage	Mean
Age (years):			
Less than 30	16	10.00	
30 – 40	44	27.50	
40 - 50	54	33.75	47
Above 50	46	28.75	
Marital Status:			
Single	7	4.38	
Married	105	65.63	
Divorced/Separated/Widowed	48	30.00	
Educational qualification:			
No Formal	35	21.88	
Primary	96	60.00	
Secondary	25	15.63	
Tertiary	4	2.50	

Source: Field Survey, 2023

Causes of conflicts in the Study Area

The percentage distribution of the respondents based on the causes of conflicts in the study area was presented in Table 2. In term of causes of conflicts in the study area as stated by the respondents, 89.38%, 84.38%, 77.50% and 63.75% of the respondents reported that religion intolerance, tribalism, selfish interest from both parties involved and communal values/norms respectively were the factors that caused conflicts between arable crop farmers and herders in the study area respectively, This implies that the peaceful co-existence between arable crop farmers and herders is had been threatened by the factors mentioned above, local leaders andreligous leaders in the area must pay due attention to the factors causing conflicts between arable crop farmers and herders in the study area.

Table 2: Distribution of the respondents based on causes of conflicts in the study area

S/N	Causes of conflicts	Always	Occasionally	Never
		Freq. (%)	Freq. (%)	Freq. (%)
1	Religion intolerance	143 (89.38)	4 (2.50)	13 (8.130
2	Tribalism	135 (84.38)	14 (8.75)	11 (6.88)
3	Illiteracy	12 (7.50)	137 (85.63)	11 (6.88)
4	Selfish interest	124 (77.50)	30 (18.75)	6 (3.75)
5	No interest in funding animals by herders	20 (12.50)	128 (80.00)	12 (7.50)
6	Ammunitions in the custody of herders	94 (58.75)	42 (26.25)	24 (15.00)
7	Government bias ethnical policies	25 (15.63)	49 (30.63)	86 (53.75)
8	Land ownership dispute	18 (11.25)	116 (72.50)	26 (16.25)
9	Climate variabilities	94 (58.75)	12 (7.50)	54 (33.75)

10	Values and norms	102 (63.75)	16 (10.00)	42 (26.25)
11	Poisonings of animals	141 (88.13)	8 (5.00)	11 (6.88)
12	Scarcity of water	86 (53.75)	65 (40.63)	9 (5.63)

Percentages are in Parentheses
Source: Field Survey, 2023

Effects of farmers – headers conflict on Arable crop production
Table 4 showed that majority (92.5%) of the respondents agreed that there had been low productivity in Arable crop production due to the effects of farmers- headers conflicts. The table further revealed that timely operations are difficult to follow (86.25%), reduction in size of farmland (83.75%), increase in price of the produce (78.13%) and harvesting of immature crops (68.13) were also the effects of farmers-herders' conflicts in the area. Among these effects, tree crops planting had replaced arable crops and scarcity of the arable crops were ranked 1st with the weighted WMS of 2.26. Ranked least were reduction in size of farm land and harvesting of immature crop with the WMS of 2.09. This implies that farmers – herders conflicts had affected the arable crop farmers negatively and they will need more tolerance and perseverance in order to remain on the farm.

Table 4. Effects of farmers-herders' conflicts on arable crop production

S/N	Statements	Agreed	Undecided	Disagreed	WMS	Rank
1	Timely operations are difficult to fellow	138(86.25)	02(1.25)	20(12.50)	2.20	5th
2	Reduction in size of farmland	134(83.75)		26(16.25)	2.09	11th
3	Wastage of crops on the farm	112(70.00)		48(30.00)	2.18	6th
4	Low productivity	148(92.5)	02(1.25)	10(6.25)	2.27	3rd
5	Tree crops planting had been replacing arable crops	45(28.13)		115(72.37)	2.36	1st
6	High cost of production	56(35.00)	04(2.5)	110(68.75)	2.17	7th
7	Arable crop production is becoming more tedious	95(59.38)	15(9.38)	50(31.25)	2.26	4th
8	Increase in price of the produces	125(78.13)	08(5.00)	27(17.34)	2.16	9th
9	Non-farm activities had been replacing arable crops production	(35.00)56	04(2.5)	110(68.75)	2.17	7th
10	Scarcity of the crops	45(28.13)		115(72.37)	2.36	1st
11	Harvesting of immature	109(68.13)	09(5.62)	42(26.3)	2.09	11th
12	Poor quality at marketing	102(63.75)	18 (11.25)	40. (2500)	2.14	10th

Percentages are in Parentheses
Field Survey, 2023

CONCLUSION AND RECOMMENDATIONS

It can be concluded from the study that the major causes of conflicts in the area were religion intolerance, tribalism, illeteracy and land ownership dispute. Based on the findings of this study, it was recommended that government should provide potable water for the populace, so as to reduce competition for water between the farmers and the cattle of the herders.

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EFFECT OF AGE ON BODY WEIGHT AND CUMULATIVE EGG PRODUCTION OF LOHMANN BROWN LAYERS IN LAFIA, NASARAWA STATE, NIGERIA

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ABSTRACT

The present study aimed at determining age effect on body weight and cumulative egg production of Lohmann Brown layers reared in Lafia, Nasarawa State. A total of forty (40) Lohmann Brown layers in cage system at the Faculty of Agriculture Livestock Farm were utilized in the study. The birds were randomly arranged in a completely randomized design. The performance parameters considered were weekly body weight (BW), (g), determined weekly and cumulative egg number (CEN) per week. The effect of age (27, 28, 29 and 30 weeks old) on weekly BW and CEN was determined using one-way analysis of variance (ANOVA) with repeated measures. Significant ($P<0.05$) means were separated with Greenhouse-Geisser correction. Logistic 3P, 4P, 5P and Gompertz 3P models were employed to predict body weight from the age of the birds. However, the relationship between cumulative egg production and age was established using linear, quadratic, and cubic regression models including the artificial neural network (ANN). Age significantly affected the weekly body weight and cumulative egg production of Lohmann Brown layers. The Gompertz 3P model offered the best fit for body weight parameters over logistic 3P, 4P and 5P models. With regard to cumulative egg production, the ANN performed better than the quadratic, linear and cubic models. In all the models, body weight and cumulative egg production were optimized at 28.5 weeks of age. This optimal value obtained, however, could change with a longer duration of study.

Keywords: *Layers, body size, eggs, age, modelling*

INTRODUCTION

Poultry farming is fast becoming an attractive business and a sub-sector which generates employment opportunities for both skilled and unskilled labor. This is due to its short gestation period and generation interval, prolificacy and lack of taboos to its production coupled with an increasing demand for its production by a large segment of the populace especially during religious and other local and national festivals. In order to meet this increasing demand, however, there is an urgent task of developing or procuring the fastest growing strain for new entrant and long-time poultry farmers considering the environmental sensitivity of every genotype (Jesuyon & Oseni, 2015).

There is strong evidence that there are genetic differences in growth rate between strains or breeds of chicken (Yakubu
& Aguda, 2020). Certain studies have shown that there are significant differences between body weight, weight gain and egg production characteristics at different ages of chicken (Yakubu et al., 2018). There is no doubt about the fact that the bird's live weight at times of commencement of egg laying determines its age at first egg production and its peak production as well as the overall performance of the hen. A hen that reaches sexual maturity earlier will produce more eggs than the one that reaches its sexual maturity later. The objective of the study was to evaluate the effect of age on bodyweight and cumulative egg number of Lohmann Brown hens kept in Battery cages in Nasarawa State, Nigeria.

MATERIALS AND METHODS

The experiment was carried out at the Livestock Section of the Teaching and Research Farm of the Faculty of Agriculture, Nasarawa State University, Keffi, Shabu-Lafia Campus, Lafia, Nigeria. A total of forty Lohmann Brown layers on cage system were utilized in the study. The birds were randomly arranged in a completely randomized design. There were four replicates each comprising ten birds. They were fed conventional commercial feed. There was appropriate vaccination and medication of the birds in line with established standards and procedures. Other routine management practices were strictly carried out. From week 27-30 of age, the performance parameters considered were weekly body weight (BW), (g), and cumulative egg number (CEN) per week. The effect of age (27, 28, 29 and 30 weeks old) on weekly BW and CEN was determined using one-way analysis of variance (ANOVA) with repeated measures. Significant means were separated at 95% confidence with Greenhouse-Geisser correction (IBM-SPSS, 2020). Logistic 3P, 4P, 5P and Gompertz 3P models wer used to predict body weight from the age of the birds. However, the relationship between cumulative egg production and age was established using linear, quadratic, and cubic regression models including the artificial neural network (ANN) (JMP, 2022).

RESULTS

There was significant ($P<0.05$) increase in body weight of Lohmann Brown birds at 30 weeks of age (2.02 g) when compared to 27 weeks old birds (1.80 g). Mean cumulative egg production was also higher ($P<0.05$) at 30 weeks of age (6.73) compared to 27 weeks of age (5.28). The Gompertz model had the best fit for modeling the growth curve of the birds, according to AIC and BIC followed by Logistics 3P, Logistics 4P and Logistics 5P (Table 1 and Figure 1). Coefficient of determination ranged from 0.643 and 0.645 for the models, indicating good fit and high ability to predict weight during the laying periods. The age at inflection point was 28.5 weeks for all the models while the body weights at inflection point were 1.903, 1.903, 1.896 and 1.896 for Gompertz, Logistics 3P, Logistics 4P and Logistics 5P. The neural network had the best fit for modeling the cumulative egg production of the birds, with a coefficient of determination of 0.756 (Table 2). It was followed by the cubic, linear and quadratic models, respectively. The neural network also had the highest number of eggs (6.01) at inflection point compared to 6.0 obtained in others. However, the age at inflection point was 28.5 weeks for all the models.

Table 1. Estimated growth curve parameters for body weight in Lohmann Brown layers

Model	A	b	C	d	e	Age and weight at inflection point	AIC	BIC	RMSE	R^2
Gompertz 3P	0.005	442.27		2474.26		28.5; 1.903	-469.086	-457.044	0.0550	0.643
Logistic 3P	0.034	304.53		24812.39		28.5; 1.903	-469.160	-457.117	0.0549	0.643
Logistic 4P	0.203	78.41	1.58	7573.31		28.5; 1.896	-468.096	-453.110	0.0549	0.645
Logistic 5P	-0.202	122.07	1.58	438892.92	114.82	28.5; 1.896	-465.936	-448.035	0.0551	0.645

AIC = Akaike information criterion; BIC = Bayesian information criterion; RMSE = Root mean square error; R^2 = Coefficient of determination; a = maturity index; b = scale parameter; c = asymptotic weight; d = upper asymptote; e = power or asymmetry parameter

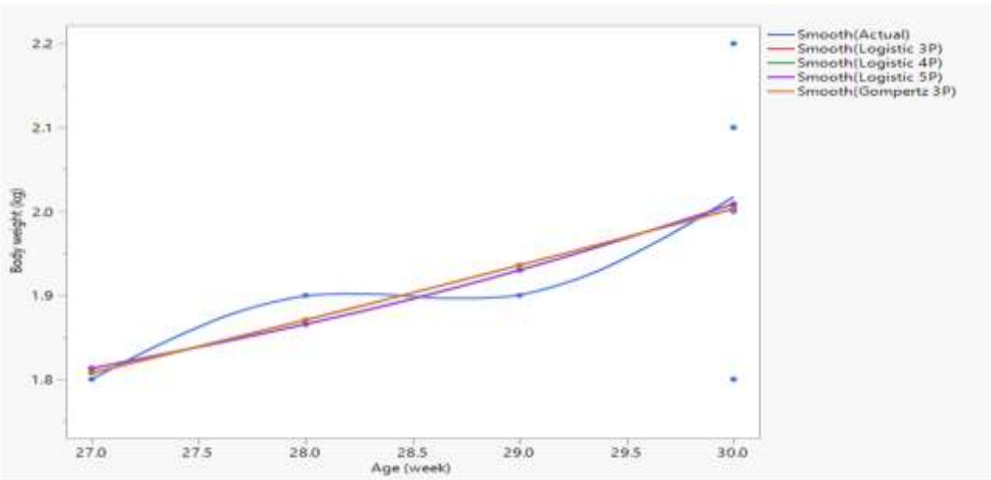

Figure 1. Growth curves of non-linear models in Lohmann Brown layers.

Table 2. Estimated cumulative egg production curve parameters in Lohmann Brown layers

Model	b_o	b_1	b_2	b_3	Age and egg number at inflection point	AIC	BIC	RMSE	R^2
Linear	-6.40	0.44			28.5; 6.00	128.739	137.810	0.357	0.653
Quadratic	-6.40	0.44	-4.971e-9		28.5; 6.00	130.843	142.886	0.358	0.653
Cubic	-5586.65	588.82	-20.66	0.24	28.5; 6.00	95.536	110.522	0.320	0.725
Neural network					28.5; 6.01			0.313	0.756

AIC = Akaike information criterion; BIC = Bayesian information criterion; RMSE = Root mean square error; R^2 = Coefficient of determination; b_0 = intercept; b_1, b_2 and b_3 = regression coefficients

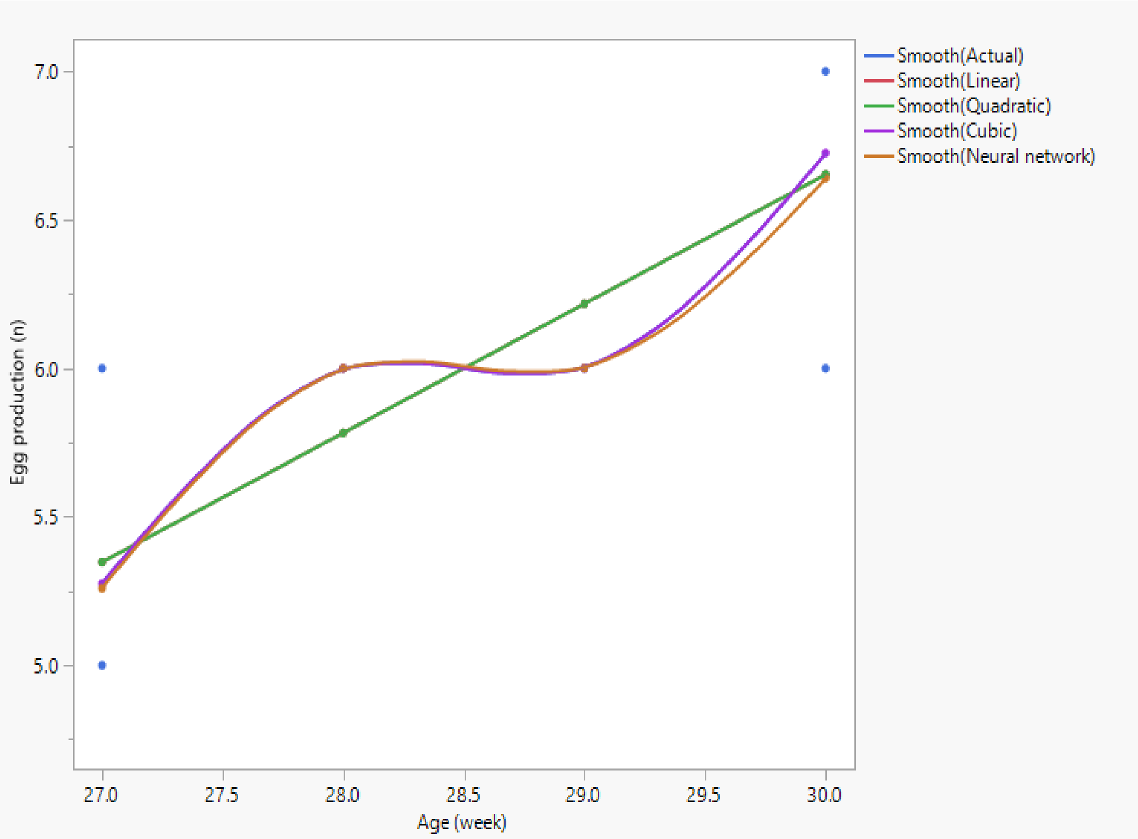

Figure 2. Actual and predicted cumulative egg number of Lohmann Brown layers.

DISCUSSION

Body weight and cumulative egg production was highly influenced by age in the current study. This is consistent with the findings of Tůmová & Gous (2012) and Şekeroğlu et al. (2014). The lowest egg production and small egg size recorded at week 27 could be due to the fact the birds had just got into laying. According to Johnston & Guos (2007), the age of hens is a very vital factor that influences egg production and egg size. They further stated that the rate of egg production increased as the age of the bird increased, and at a particular age of about 70 weeks, egg production began to decline gradually. It has been reported that older birds of about 70 weeks and above have a larger preovulatory follicle and oviduct compared to younger birds. Modelling production parameters of laying hens permits a good understanding of the production cycle. This might be exploited in decision making especially where there is an unexpected decline in production at a particular phase. To validate a regression function or estimate, the R^2 is taken often (Olaniyan et al., 2017). The current observation is not consistent with the submission of Yakubu & Madaki (2017) where the prediction of body weight from age (weeks) using the quadratic model gave R^2 and adjusted R^2 values of 0.852 and 0.852, respectively. Also, the current optimal body weight at 28.5 weeks is lesser than the 47.5 weeks of age reported by Yakubu & Madaki (2017). The differences could be due to genetic factor, plane of nutrition, management and the length of egg collection.

Several authors have adopted different models in the layer–type birds to predict performance characteristics (Narinc et al., 2014; Selvaggi et al., 2015; Okoro et al., 2017; Safari−Aliqiarloo et al., 2018). In poultry farms, optimum production time estimation is very important as regards economic production. The determination of the best performance of birds at appropriate ages may be exploited in the improvement of farm output. The set of values obtained in the present study could guide management decisions on the use of resources to reduce wastage and losses while maximizing economic gains in the poultry farms.

CONCLUSION

Age significantly affected the weekly body weight and cumulative egg production of Lohmann Brown layers. The Gompertz 3P model offered the best fit for body weight parameters over logistic 3P, 4P and 5P models. With regard to cumulative egg production, the neural network performed better than the quadratic, linear and cubic models. In all the models body weight and cumulative egg production were optimized at 28.5 weeks of age. This could however change when the period of study is elongated.

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CARCASS AND ORGAN WEIGHTS CHARACTERISTICS OF FINISHER BROILER CHICKENS FED PRO-VITAMIN A (UMUCASS 36) CASSAVA MEAL.

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ABSTRACT
A 4-week study was conducted using 120 unsexed Anak strain broilers to determine the carcass and internal organs characteristics of finishing broilers fed unpeeled and peeled fermented pro-vitamin A cassava meal as total replacement for maize. Fresh bio-fortified pro-vitamin A cassava was harvested and divided into two batches. The first batch was peeled and the second batch was unpeeled. Both were soaked separately in a plastic vat containing clean water and allowed to ferment for 72 hours. Thereafter, they were washed with clean water, sundried and milled to produce i. peeled fermented pro-vitamin A cassava tuber meal (PFPC). ii. Unpeeled fermented pro-vitamin A cassava tuber meal (UFPC). The broilers were divided into three groups and fed diets containing 100% maize T_1 (control) as the source of energy, while T_2 and T_3 contained 100% unpeeled and peeled fermented pro-vitamin A cassava as the source of energy respectively. Each group was replicated four times with 10 birds per replicate in a completely Randomized Design. Feed and water were provided ad libitum for the period. Result showed that final body weight, daily weight gain and breast weight of the control were significantly ($p<0.05$) higher than UFPC and PFPC groups. The treatment had no significant ($p>0.05$) effect on the internal organs of the birds. Abdominal fat of the PFPC group was significantly ($p<0.05$) higher than the control and UFPC. The results of this study revealed that unpeeled and peeled fermented pro-vitamin A cassava meal may completely replace maize in the diets of finishing broilers.
Keywords: *Broiler, pro-vitamin A cassava*

INTRODUCTION
Provision of feed is the most important consideration in poultry enterprise. Feed alone has been reported to account for 60-80% of the total cost of poultry production in developing countries (Igboeli, 2000; Esonu, *et al*., 2001). Maize contribute 55% of the total cost of poultry diets. Limitations imposed by scarcity and high cost of maize due to its consumption by humans, has forced many farmers into employing other readily available alternative source of energy such as cassava.

Cassava is one of the alternative energy sources that can replace a considerably proportion of maize in livestock feed industry (Bokanga1995). Its products have been in use for a long time in place of cereal grains for livestock (Eruvbetine *et al.*, 2014). In order to reduce the high level of toxic cyanogens, increase in shelf-life and vitamin A content in cassava, provitamin A also known as UMUCASS 36 bio-fortified cassava was introduced by plant breeders who conducted series of crosses among selected parents and also evaluate their promising progenies for over 10 years (Khajarern,1997).

Research on the potentials of pro-vitamins A cassava has not been fully explored as animal feed stuff, therefore, the aim of this research was to assess the potentials of pro-vitamin A cassava as a source of energy on the carcass and internal organs of finishing broilers.

MATERIALS AND METHODS
Experimental Site
The experiment was carried out at the Poultry Unit, Teaching and Research Unit of Michael Opara University of Agriculture, Umudike in Abia State. The area lies within the latitude 5^0 29' North and longitude 7^0 32΄΄East, the altitude is 122m above sea level with relative humidity of about 50-95%, temperature range of about 22-36^{0}C

Source of pro-vitamin A variety of cassava and Processing Method
The fresh pro-vitamin A variety of cassava (UMUCASS 36) tubers were obtained from National Root Crops Research Institute Umudike, Abia State. The tubers were divided into two batches. One batch was peeled and the

other was left unpeeled. The peeled and the unpeeled tubers were washed and later soaked in separate plastic Vat containing clean water and allowed to ferment for 72 hours. Thereafter, the fermented tubers were washed, sundried for 3-4 days and run through a hammer mill using 2mm sieve to homogenized it thereby producing; i) unpeeled fermented pro-vitamin A cassava tuber meal (UFPC) and ii) Peeled fermented pro-vitamin A cassava tuber meal (PFPC)

Experimental Diets

Three experimental diets T_1, T_2 and T_3 were formulated such that T_1 (control) had maize as source of energy, T_2 and T_3 contained 100% UFPC and PFPC respectively; completely replacing maize in the diet. Other ingredients were adjusted such that the diet met nutrient requirement of finishing broilers. The ingredients composition of the experimental diets is shown in table 1.

Experimental Birds and Design

One hundred and twenty broiler chickens of mixed sexes (Anak Strain) obtained from a local hatchery were used for the experiment. The broilers were brooded for 3 weeks and fed with normal feed while the test ingredient were used for the experiment proper. At 35- day of age, the birds were divided into 3 groups of 40 birds each and each group were randomly assigned one of the three experimental diets using Completely Randomized Design . Each group was further replicated 4 times and with 10 birds per replicate. Feed and water were provided *ad-libitum*. All necessary prophylactic medications and vaccinations were also provided.

Carcass and Internal Organ Evaluation

At day- 63 four birds were randomly selected from each treatment, starved of feed overnight but provided with water, weighed and sacrificed by cutting their jugular vein. The carcasses were scalded in hot water of about 80ºC for a minute and the feathers were plucked manually. The carcasses were eviscerated by cutting through the vent and the viscera were removed. Weights were obtained for edible carcass parts; drumstick, thigh, shank, back, wings and breast. Weights of internal organs were also determined (gizzard, liver, kidney and heart). The dressed carcasses weights were expressed as percentage of live weight.

Data Analysis

Data generated were subjected to analysis of variance in a statistical analysis System package (Delapenha and Jhanelle, 2020) The means were compared using Duncan New Multiple Range Test (DNMRT) as outlined by (Obi 1990).

RESULTS AND DISCUSSION

Table 1 shows the carcass, cut-up parts and internal organs evaluation of finishing broiler chicken fed pro-vitamin A variety of cassava tubers. The live weight, dressed weight and dressing percentages of birds in the control were higher than the UFPC and PFPC groups. The cut-up parts; thigh, drumstick, back, wing and neck were not significantly ($p>0.05$) affected by the diet except breast. The value for breast in the control was significantly ($p<0.05$) higher than the UFPC and PFPC groups.

The dietary treatment had no significant effect ($p>0.05$) on the internal organs of the birds. The group of PFPC diet developed significantly ($p<0.05$) more abdominal fat than the control and UFPC group. Similar observations had been made by Adedokun *et al.* (2017) and Udedibie *et al.* (2008).

Table 1: Carcass, Cut-up parts and Internal Organs Evaluation of finishing broiler Chicken fed pro-vitamin A variety of cassava tubers

Parameter	T_1control	T_2 UFPC	T_3 PFPC	SEM
Live weight (kg)	2.53^a	2.37^b	2.39^b	1.12
Dressed weight (kg)	1.61 ^{a}	1.46^b	1.49^b	0.03
Dressing percentage (%)	63.63^a	61.09^b	62.34^b	1.16
Abdominal fat (%)	1.58	2.31	2.51	0.17
Relative cut-up parts (% of LW) Breast	31.88^a	29.86^b	29.78^b	0.15
Thigh	24.13	23.57	23.71	1.03
Drumstick	19.65	19.21	19.34	0.13
Back	22.57	22.32	21.87	0.15
Wing	12.50	12.41	12.39	0.06
Neck	6.97	6.54	6.71	1.08
Relative organ weight (%of LW) Liver	2.53	2.37	2.39	0.13
Gizzard	2.64	2.71	2.78	0.17
Heart	0.50	0.56	0.56	0.19
Kidney	0.25	0.20	0.24	0.01

ab – means within rows with different superscripts are significantly ($p<0.05$) different

Cassava has been widely used to replaced maize in poultry diets but the results in terms of its feeding value, nutritional problems encountered, biological responses and productive performances of chickens fed cassava products has always exhibited wide variability (Khajarern, 1997). This is because of the presence of toxic cyanogenic glycoside but with the introduction of bio-fortified cassava (pro- vitamin A (UMUCASS 36) which was used in this study that contain insignificant level of HCN and fermentation method which is regarded as the best method for detoxification of tuberous crops (Adedokun *et al.*2017). This method was also used in this study to process the cassava thus would have helped to reduce the effect of HCN toxicity on the birds, however the higher body weight gain recorded by the control over the UFPC and PFPC group could be attributed to the level of protein content of the feed ingredients (maize and cassava). The protein content in maize is higher and of a better quality than cassava (Oker, 2011) reported that feed quality affects the growth performance of chickens. The liver, kidney, heart and gizzard of the birds were not affected by the diet. There was no observed abnormality on the internal organs. The liver, kidney and heart weights indicated that both UFPC and PFPC diets did not apparently inflict them with toxicity. The non significant ($p>0.05$) effect of the gizzard showed that the control, UFPC and PFPC diets were finely ground; there were no structural components such as hulls, cereal particles and wood shaving in diets.

CONCLUSION

The information presented in this study herein has strongly shown that feeding broiler birds with unpeeled and peeled fermented pro-vitamin A cassava (UMUCASS 36) as a reference diet to maize may improve the carcass characteristics with little or no adverse effect. It is therefore suggested that pro-vitamin A cassava could be used in poultry diets as total replacement for maize but the diet should be formulated in a way to balance the disparity inherent in crude protein content of cassava and maize, respectively.

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EFFECT OF FEEDING VARYING LEVELS TIGERNUT (*CYPERUS ESCULENTA VAR SATIVUS*) MEAL ON NUTRIENT DIGESTIBILITY OF FEMALE WEANER RABBIT.

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ABSTRACT

This experiment was conducted to determine the effect of feeding varying levels of tigernut meal on nutrient digestibility of female weaner rabbits at graded levels of inclusion (0%=T_1, 10%=T_2, 20%=T_3 and 30%=T_4). Twenty-four (24) clinically, healthy female weaner rabbits were used in the experiment to evaluate the effect of feeding varying levels of tigernut meal diet which was randomly divided into 4 groups of 6 animals per treatment with 2 animals per replicate giving 3 replicate per treatment, in a completely randomized design (CRD). Water and feed were given ad libitum. The experiment lasted for 120 days. Simple Descriptive Statistics and Analysis of Variance (ANOVA) were used to analyze the data while the New Duncan's Multiple Range Test was employed to compare treatment means. The dry matter (DM) and crude protein (CP) digestibility values were improved ($P<0.05$) by dietary treatments. This study revealed that tigernut meal is rich in carbohydrate, it also showed that the tigernut meal could be used as a partial or total replacement for maize at upto 30% level of inclusion without any adverse effect on the growth and reproductive performance of the female weaner rabbits.

INTRODUCTION

The high cost of maize as the main energy source for livestock and rabbit feeds and a staple food for Nigerians and Agro-allied companies including brewing industries cannot be over- emphasized. The resultant effect is high cost of animal protein hence inability of the populace to meet the minimum dietary protein intake of 56g per person per day as recommended by the. Food and Agricultural Organization of the United Nation (Fasuyi, 2005). Many attempts have been made to solve this problem through the use of some non-conventional energy sources in poultry such as maize offal (Vantsawa *et al.*, 2008), palm oil sludge (Esonu *et al*., 2006), cassava (Udedibie *et al*., 2009) and in rabbit nutrition, wild variegated cocoyam (Agbabiaka *et al.*, 2006), cocoyam corm (Omorege *et al*., 2009, Aderolu and Sogbesan, 2010). These tuber crops have been found to be of good potential but with limited crude protein content which is often below 3%. Tigernut (*Cyperus esculentus* L.) has been reported to be rich in energy while its oil content (about 25%) is resistant to peroxidation (Belewu and Belewu, 2007).

Tiger nut is a tuber rich in energy content (starch, fat, sugar), minerals (mainly phosphorus and potassium), and vitamins E and C thus making the tuber also suitable for diabetic patients to take (Ekeanyanwu and Ononogbu, 2010).

MATERIALS AND METHODS

The experiments were carried out at the Rabbitary Unit of the Teaching and Research Farm of Abia State University, Umuahia Location. The Campus is located within the Southeastern Nigeria and lies between Longitude 07º 33ꞌ E and Latitude 05º 29ꞌ N at about 8km East of the Umuahia-Ikot Ekpene road. It is 140 km North of Port Harcourt International Airport, 135 km South of Enugu Airport and 80 km East of Owerri Airport. The experiment lasted for 120 days. The tiger nut seeds were purchased from "Ama Hausa" in Umuahia in Abia State, Nigeria. The milling was done at Feed Mill Unit of National Root Crops Research Institute, Umudike. Twenty-four (24) female weaner rabbits were used for the experiment and were assigned to the four treatment diets following the Completely Randomized Design (CRD). where each treatment had six rabbits which was further replicated 3times with 2 rabbits per replicate and the breed used for the studies was New Zealand White with an average weight of 980g and 6-8 weeks of age. The rabbits were purchased from the rabbit unit of National Root Crops Research Institute, Umudike.

The rabbits were housed in galvanized metal hutches measuring 100×60×80cm^3. The hutches were placed in an open sided house with corrugated roofing sheets, the side walls built up to 1meter high and the remaining part of the sides covered with wire mesh.Four treatment diets containing 0%, 10%, 20% and 30% tigernut meal were compounded.

RESULTS AND DISCUSSION

Nutrient digestibility

The digestibility result is presented in Table 1. The result showed that the values of rabbits fed 0% (77.21%) and that of 10% (72.15%) diet were same statistically. They also indicated that rabbits fed 10% diet had no problem in digesting the dry matter in the diets contrary to those fed 30% diets. It therefore showed that rabbits fed 10% tigernut meal had better and superior dry matter digestibility than treatments 3 and 4.

Crude protein digestibility showed no significant difference (P>0.05) between rabbits fed 0 and 10% tigernut meal diets but differed significantly (P<0.05) from rabbits fed 20%(52) and 30% (51.06) diets which were statistically similar (P>0.05). In this study it was observed that rabbits fed tigernut meal were able to digest crude protein at a decreasing rate as the level of inclusion increased. The reason for the poor digestibility at 30% maybe attributed to higher concentrations of tannins, phytate, etc. These observations agreed with the findings of Sathe and Salunke, (1981).

Ether extract digestibility was highest in rabbits under treatment 1 (63.45%) followed by T_2 (61.31%), T_3 (53.35%) and T_4 (48.35%) respectively. Rabbits on T_1 and T_2 had similar (P>0.05) digestibility but they differed significantly from rabbits on 20 and 30% levels of inclusion. Rabbits on 20% level of inclusion differed significantly (P<0.05) from those on 30% (T_4) level of inclusion.

Nitrogen free extract digestibility had significant difference (P<0.05) between treatments 4 and 3, but had higher non-significant difference between treatments 2 and 1.

Crude fibre digestibility was significantly different among the treatments. The values were 53.25, 55.45, 61.18 and 62.33% for T_1, T_2, T_3 and T_4 respectively. The difference in digestibility between rabbits on T_1 and T_2 was not significant (P>0.05) but they differed significantly (P<0.05) from rabbits on T_3 and T_4 which were statistically similar (P<0.05). The observed trend in nutrient digestibility was that the digestibility of DM, CP, EE and NFE declined as the level of tigernut meal increased in the diet. However, CF digestibility increased as the level of tigernut meal in the diet increased. This may be due to the fact that tigernut meal contains about 12.4% CF (Ladeji *et al.*, 2003).

Table 1. Effect of Tigernut meal on Nutrient Digestibility of various diets in female rabbits

	Treatments of dietary levels of tigernut meal (%)				
Parameters	**T_1 (0%)**	**T_2 (10%)**	**T_3 (20%)**	**T_4 (30%)**	**SEM**
Dry matter (%)	77.21^a	72.15^a	56.00^b	53.00^b	5.95
Crude protein (%)	70.25^a	63.50^a	52.00^b	51.06^b	4.64
Ether extract (%)	63.45^a	61.31^a	55.34^b	52.30^b	2.58
Nitrogen free extract (%)	84.21^a	77.30^a	53.35^b	48.35^c	8.81
Crude fibre (%)	53.25^a	55.45^b	61.18^a	62.33^a	2.20

a, b, c: Means with different superscript on the same row differ significantly (P<0.05).

The proximate composition of the experimental diet

The results in the Table 2 of this study established that tubers of *C. esculentus* diet compared favourably with the control that had no tigernut. The results showed that the proximate composition of the diet in dry matter and crude fibre indicated no significant (P>0.05) differences among 0%, 10%,20% and 30% levels of inclusion of tigernut meal. In crude protein there were no significant difference (P>0.05) between T_2, T_3 and T_4 respectively but differed (P<0.05) slightly from T_1. In Ash there were significant difference (P<0.05) between T_1, T_2, T_3 and T_4 respectively while T_2 and T_4 had no significant difference (P>0.05). In ether extract there were no significant between (P>0.05) T_1 and T_2 but differed significantly (P<0.05) from T_3 and T_4. Nitrogen free extract showed no difference (P>0.05) between T_1 and T_2 but differed significantly (P<0.05) with T_3 and T_4 as T_3 and T_4 had no significant difference (P>0.05) between them. In metabolisable energy the result showed no difference (P>0.05) between T_1 and T_2 but differed significantly (P<0.05) with T_3 and T_4 as T_3 and T_4 had no significant difference (P>0.05) between them. The proximate composition of the experimental diet offered the normal nutrition required for maximum performance.

Table 2. Proximate Composition of the Experimental Diet (%DM)

	Concentration (%)			
Parameters	**T_1 (0%)**	**T_2 (10%)**	**T_3 (20%)**	**T_4 (30%)**
Dry matter (DM)	86.00	88.20	87.00	90.00
Crude protein (CP)	14.94[b]	15.75[a]	16.19[a]	16.50[a]
Crude fibre (CF)	3.10	3.00	3.13	3.20
Ash	18.80[c]	26.00[a]	20.00[b]	25.00[a]
Ether extract (EE)	6.60[c]	6.00[c]	7.70[a]	7.10[b]
Nitrogen free extract (NFE)	43.56[a]	41.04[a]	33.21[b]	31.30[b]
Metabolisable energy (Kcal/kg)	2311[a]	2242.7[a]	1899.1[b]	1945[b]
Atwater 1978.				

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ANALYSIS OF FARMERS AND PASTORALISTS WILLINGNESS TO USE ALTERNATIVE DISPUTE RESOLUTION (ADR) STRATEGIES IN CONFLICT RESOLUTION IN NASARAWA STATE, NIGERIA

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ABSTRACT
This study analysed farmers and pastoralists willingness to used Alternative Dispute Resolution (ADR) strategies in conflict resolution in Nasarawa State, Nigeria. Three-stages sampling techniques was used to select one hundred and sixty farmers and fifty-one pastoralists. Structured questionnaire complimented with interview scheduled were used for data collection. Data collected were analysed using frequency percentage, mean and Kendall Coefficient of Concordance. Result of the farmers willingness to used ADR elucidated that ADR is restorative ($\bar{X}$ =4.13), ADR is easily accessible to the poor and vulnerable ($\bar{X}$ =4.05), panellists involved in ADR are highly experienced ($\bar{X}$ =4.01) and ADR focus on understanding issues better ($\bar{X}$ =4.01). The pastoralists indicated that ADR provide a model for quick dispute resolution ($\bar{X}$ =4.29), ADR provides flexible means of resolving conflict ($\bar{X}$ =4.23) and ADR focus is on understanding issues better ($\bar{X}$ =4.18). Farmers reported that dialogue/convening a meeting ($\bar{X}$=15.43), mediation by `elders ($\bar{X}$=14.58), tendering apology ($\bar{X}$=14.16) were the most strategies used for improving relationship with pastoralists while pastoralists reported that compensation and punishment ($\bar{X}$=17.22), tendering apology/use of negotiation ($\bar{X}$=13.76), dialogue/conveying meeting ($\bar{X}$=12.69) were the most strategies used for improving relationship with farmers. It is recommended that curfew should be proactively used in curbing conflict. Sanction should be apportioned to the offenders in order to correct abnormities. Lastly, democratic approaches should be used by agents in conflict resolution.
Keywords*: Farmers-Pastoralists, Willingness, ADR, Conflict Resolution*

INTRODUCTION
Farmers and pastoralists conflict have been a dwindling issue affecting many countries Nigeria inclusive. The country has witnessed the re-occurrence of farmers and pastoralists' disputes in the past, which has not only deteriorated farmers and pastoralists relationshipsbut also resulted in losses of lives and properties. The occurrence of conflict is always associated with the struggle for inadequate resources and egocentricity. Also, conflict creates an avenue for dispute resolution, and dispute resolution can reduce or eliminate causes of underlying conflictwith the agreement of both parties involved (Mwajaide *et al.*, 2015). Alternative Dispute Resolution (ADR) is one of the solution to re-concurrent farmers-pastoralists conflicts in Nigeria. ADR encompasses all legally permitted processes of dispute resolution other than litigation (Ibrahim, 2014). It is also seen as an umbrella term that refers to general, alternatives to court adjudication of disputes such as negotiation, mediation, arbitration, minitrial and summary trial (Nformi *et al.,* 2014). ADR has been useful in restoring farmers and pastoralists relationships in the past with other traditional means of dispute resolution. On the effectiveness of the strategies employed for improved farmer-pastoralist relationship Olaleye *et al.* (2010) identified the following strategies to include; intervention by traditional leaders, payment of compensation to victims, court verdicts, dialogue between parties involved, the intervention of Miyetti Allah cattle breeders association, local community crop farmers/herders intervention and establishment of grazing routes, educating farmers and herders by person or bodies responsible

for conflict resolution. The objectives of the study were; to determine the willingness of farmers and pastoralists to use ADR and examine the ADR strategies used in improving farmers-pastoralists relationship

METHODOLOGY

The study was conducted in Nasarawa State. The State is located between Latitudes 7 º and 9' N and Longitudes 7 º and 10' E. Nasarawa State has a land area of 28,735 square kilometers and is divided into thirteen (13) Local Government Areas (LGAs). The 2006 population census pegs the state's population at 1,863,275million, the projected population as of 2018 using a 2.5% growth rate is 2,456,955 million (Nasarawa State Agricultural Development Programme [NSADP], 2016). The major crops produced are cassava, yam, rice, maize, guinea corn, cowpea, soya bean, acha, melon and millet. However, animals such as Goat, Sheep, Cattle, and Pig were reared in the State (NSADP, 2016). Three-stage sampling technique was used to select respondents from the study area. The first stage involved the purposive selection of three (3) Local Government Areas' agricultural zones, namely: Akwanga, Awe and Karu making a total of three (3) Local Government Areas. The second stage involved random selection of three (3) villages from each of the Local Government Areas selected making a total of nine (9) villages. The third stage involved the use of proportional sampling to select 10% of the farmers as presented in Table1. Snowball sampling method was used for the pastoralists through the help of their umbrella body Miyetti Allah Cattle Breeders Association of Nigeria (MACBAN) in each State. The leadership assisted the researcher to select one pastoralist who assisted in locating other pastoralists due to their nature of settlement (*Rugage*). A total of fifty-one (51) herdsmen were targeted.

Table 1: Sample distribution of the farmers in the study area

State	Zones	LGAs	Villages	Sampling frame	Sample size (10%)
Nassarawa State	Central	Akwanga	Nunku	210	21
			Anjida	173	17
			Aricha	101	10
	Southern	Awe	Tunga	160	16
			Azara	240	24
			Baure	152	15
	Western	Karu	Ankoma	141	14
			Gitata	240	24
			Panda	210	21
Total	**3**	**3**	**9**	**1627**	**160**

Source: NSADP (2016)

Primary data was used for this research. Data were collected by researchers assisted by trained enumerators using structure questionnaires and interview schedules.

Analytical Techniques

Willingness to use ADR: This was achieved using 5 points Likert scale of strongly agreed =5, agree=4, undecided=3, disagree=2 and strongly disagree=1. These were summed together that is 5+4+3+2+1 and be divided by 5 to arrive at a mean value of 3. The decision: <3=not willingness to use ADR=0, $\geq$3 = willingness to use ADR.

Kendall's coefficient of concordance

To examine alternative dispute resolution strategies being used in improving farmers-pastoralists relationship was achieved using Kendall's coefficient of concordance (*W*) described by Mattson was used to rank the problems. A lower mean rank indicates the problem is severe and vice versa. The Kendall's *W* was computed as shown below.

$$W = \frac{12\sum R^{-2} i - 3N(N-1)^2}{N(N-1)}$$

Where:

W = Kendall's value, *N* = total sample size, *R* = mean of the rank. Kendall's coefficient of concordance (*W*) is a measure of the extent of agreement or disagreement among farmers of the rankings obtained. The value of *W* is positive and ranges from zero to one where one denotes perfect agreement among farmers of the rankings and zero denotes maximum disagreement.

RESULT AND DISCUSSION

Willingness of Farmers and Pastoralists to use ADR

Table 1 indicated that farmers were willing to use ADR because ADR is restorative ($\bar{X}$ =4.13), ADR are easily accessible to the poor and vulnerable ($\bar{X}$ =4.05), the panellists involved in ADR are highly experienced ($\bar{X}$ =4.01), ADR focus on understanding issues better ($\bar{X}$ =4.01), ADR provide flexible means of resolving conflict ($\bar{X}$ =3.84), ADR is expected to provide a model for quick dispute resolution and ADR is a cheaper means of resolving conflict($\bar{X}$ =3.8), ADR provides strict confidentiality ($\bar{X}$ =3.68) and parties have equal control over the outcome ($\bar{X}$ =3.65). Table 1 indicated that pastoralists are willing to use because; ADR provide a model for quick dispute resolution ($\bar{X}$ =4.29), ADR provide flexible means of resolving conflict ($\bar{X}$ =4.23), ADR focus is on understanding issues better ($\bar{X}$ =4.18), ADR preserve relationship ($\bar{X}$ =4.16), ADR is easily accessible to the poor and vulnerable ($\bar{X}$ =4.09), the panelists involved in ADR are highly experienced ($\bar{X}$ =4.04), ADR maintains a cooperative approach($\bar{X}$ =3.98) and ADR is a cheaper means of resolving conflict($\bar{X}$ =3.94). This finding denotes that ADR restore relationship, by ensuring farmers and pastoralists have equal right to judgment. Also, the outcome is always communicated in the common language understand by the pastoralists and the strategies allows both farmers and pastoralist involved to contribute their inputs without partiality, favoritism, sentimentalism and other vices that could disrupt peace in the study area (Uwazie, 2011).

Table 2: Distribution of respondents according to willingness to use ADR

Variables	Farmers (n=160) Mean ($\bar{x}$)	R `	Pastoralists (n=51) Mean ($\bar{x}$)	R
ADR provide a model for quick dispute resolution	3.83	6th	4.29	1st
ADR provide flexible means of resolving conflict	3.84	5th	4.23	2nd
ADR is a cheaper means ofresolving conflict	3.83	6th	3.94	8th
ADR are easily accessible to the poor and vulnerable	4.05	2nd	4.09	5th
ADR is restorative	4.13	1st	3.92	9th
ADR maintains a cooperative approach	3.16	16th	3.98	7th
ADR preserve relationship	3.48	12th	4.16	4th
ADR provides strict confidentiality	3.68	8th	3.53	13th
Pasrties involved in the conflict have control over the process	3.32	14th	3.23	18th
No language barrier	3.29	15th	3.25	17th
ADR is non-partisan in nature	3.44	13th	3.45	14th
ADR does not require adherence to rules and evidence	3.11	17th	3.45	14th
ADR eases tension between disputants	3.02	18th	3.18	19th
ADR is a less restrictive form of dispute resolution	3.58	11th	3.70	12th
The panelists involved in ADR are highly experienced	4.01	3rd	4.04	6th
Parties have equal control over the outcome	3.65	9th	3.78	10th
The focus is on understanding issues better	3.91	4th	4.18	3rd
ADR is democratic in nature	2.92	19th	3.78	10th
ADR encourage parties to agree on a fair settlement	3.61	10th	3.45	14th
ADR is a win-win situation	2.63	20th	2.76	20th

Source: Field survey, 2019 Key: R=Rankin

Table 3: Distribution of ADR Strategies used in improving farmers-pastoralists relationship

Variables	Farmers (n=160) Mean ($\bar{x}$)	Rank	Pastoralists (n=51) Mean ($\bar{x}$)	Rank
Imposing a curfew on the area	10.94	15th	10.31	18th
Use of propaganda	8.15	20th	9.88	21st
Setting of judicial committee	11.96	10th	10.96	13th
Use of agents to monitor conflict	12.47	7th	12.47	4th
Compensation and punishment	11.70	11th	17.22	1st
Traditional oath taking	11.20	13th	10.53	16th
Reward	10.01	17th	11.18	11th
Informal settlement	12.47	7th	11.61	8th
Mediation by elders	14.58	2nd	12.04	5th
Dialogue/convening a meeting	15.43	1st	12.69	3rd
Reconciling both parties	14.16	3rd	12.04	5th
Tendering apology	14.16	3rd	13.76	2nd
Persuasion of actors	8.91	19th	10.53	16th
Inculcation of myths	7.81	21st	9.88	21st

Ritual treaties/blood covenant	7.73	22nd	10.10	20th
Use of sanction	9.59	18th	10.31	18th
Good governance	10.27	16th	10.75	15th
Use of marriage	11.03	14th	11.39	9th
Peace education/teaching	11.37	12th	11.18	11th
Check and balances	12.30	9th	10.96	13th
Effective communication	12.80	6th	11.82	7th
Inter-faith dialogue	13.99	5th	11.39	9th
Kendall's W	0.196		0.197	
Chi-Squared	657.190***		210.551***	
Friedman	657.190***		210.551***	
Degree	21		21	
Asymptotic significant	1%		1%	

Source: Field survey, 2019

ADR Strategies used in Improving Farmers-Pastoralists Relationship

Table 3 elucidates the distribution of ADR strategies used in improving farmers-pastoralists relationship.The finding according to farmers indicated Kendall's coefficient of concordance of 19.6% level of probability while that of pastoralists was 19.7%. The finding elucidated a weak agreement among the strategies. The low Kendall value recorded might be due to error term or low agreement by farmers on the outcome among the variables included in the model. Farmers in the study area Elucidated that dialogue/convening a meeting ($\bar{X}$=15.43), mediation by `elders ($\bar{X}$=14.58), tendering apology ($\bar{X}$=14.16), reconciling both parties ($\bar{X}$=14.16), inter-faith dialogue ($\bar{X}$=13.99), effective communication($\bar{X}$=12.80), informal settlement ($\bar{X}$=12.47), use of agents to monitor conflict ($\bar{X}$=12.47), check and balances ($\bar{X}$=12.30), setting of the judicial committee ($\bar{X}$=11.96), compensation and punishment ($\bar{X}$=11.70), peace education/teaching ($\bar{X}$ =11.37), and traditional oath-taking ($\bar{X}$ =11.20) were the ADR strategies used in improving farmers-pastoralists relationship. The pastoralists reported that compensation and punishment ($\bar{X}$=17.22), tendering apology/use of negotiation ($\bar{X}$=13.76), dialogue/conveying meeting ($\bar{X}$=12.69), use of agents to monitor conflict occurrence ($\bar{X}$=12.47), mediation by elders ($\bar{X}$=12.04), reconciling both parties ($\bar{X}$=12.04), effective communication ($\bar{X}$=11.82), informal settlement ($\bar{X}$=11.61), interfaith dialogue ($\bar{X}$=11.39) and use of marriage ($\bar{X}$=11.39) were the strategies used in improving farmers-pastoralists relationship.

ADR Strategies used in Improving Farmers-Pastoralists Relationship

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CONCLUSION AND RECOMMENDATIONS

Based on this study it can be concluded that ADR is restorative, ADR is easily accessible to the poor and vulnerables. The panellists involved in ADR are highly experienced and that is the reasons behind farmers' willingness to use ADR. Pastoralists were willing to use ADR and it provides a model for quick dispute resolution, ADR provides flexible means of resolving conflict and focuses on understanding issues better. Farmers reported that dialogue/convening a meeting, mediation by elders and Reconciling both parties were used in improving relationship with pastoralist while the pastoralists reported that compensation and punishment, mediation by elders and tendering apology were effectively used in improving relationship with farmers. It is recommended that curfew should be proactively used in curbing conflict in the study area. Sanction should be apportioned to the offenders in order to correct abnormities. Lastly, democratic approaches should be used in conflict resolution in the study area.

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EFFECTS OF FARMER -PASTORALIST CONFLICTS ON EXTENSION SERVICE DELIVERY IN NIGER STATE, NIGERIA

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ABTRACT

The study investigated the effects of farmer-Pastoralist conflict on agricultural extension service delivery in the study area. Data were collected primarily by administering questionnaires to 50 respondents. Data were analyzed using descriptive statistics. Results of the study shows that average age and years spent in school were 35 years and 10years while the major perceived causes of conflicts include increased pressure on land ($\bar{X}$ =4.56), Search for water and pastures ($\bar{X}$ =4.10) and population growth. More so, results from the study also showed that the effects of farmer-Pastoralist make extension work difficult ($\bar{X}$ =4.42, delay in completion of extension work ($\bar{X}$ =4.38) and monitoring farmers progress becomes difficult ($\bar{X}$ =3.32). Constraints faced by extension agent were bad road ($\bar{X}$ =4.34), Re-occurrences of farmers-Pastoralist conflicts ($\bar{X}$ =4.1) high cost of transportation ($\bar{X}$ =3.86) and inadequate cooperation from community leaders ($\bar{X}$ =3.22). The study recommends that government should adopt policies that would tackle the causes of farmer-pastoralist conflict in the study area especially in the case of land control measures, provision of basic infrastructural facilities such as roads, water points and ranches in the study area in other to facilitate effective communication, implementation and functioning of extension workers. There is also need to set up reconciliation committees in the communities.

Keywords: *Conflicts, Farmer-pastoralist, Extension services, Extension agents and Farmers*

INTRODUCTION

Agricultural extension is a science of social change with the basic purpose of increasing farmer's productivity through efficient production. It therefore emphasized among other things like the use of fertilizer, improved seed and chemicals. Agricultural extension services assist farm people through educational procedures, improving farming methods and technique increasing production, efficiency and income satisfying their levels of living and lifting the social and educational standard of living a rural life. Pastoralism often has mobile aspects but can take many forms and be at different scales. The increase in pressure resulting from resource degradation and scarcity natural resources has aggravate the situation of competition between farmers and pastoralists. In the area where the two-production system interacts, both communities are increasingly considering the option of expansion to each other's holding. As a result, conflicts are getting recurrent and intensified in many parts of the country, this is supported by Blench (2003) that farmer pastoralist conflicts are increasing both in terms of recurrent and intensity. The farmer- Pastoralist conflict is one of the most complex social problems affecting Nigeria's survival as it has direct impact on the survival of those involved who the country depends heavily on, in terms of provision food and raw materials for industry and export in order to meet ever-growing demands.

Table 1: Socio-economic characteristics of respondents

Variables	Frequency	Percentage (%)	Mean
Age(years)			
31years and below	9	18.0	35
31-40years	33	66.0	
41-50years	8	16.0	
Gender			
Female	14	28.0	

Male	36	72.0	
Marital status			
Married	40	80.0	
Single	7	14.0	
Widowed	3	6.0	
Household size			
6 and below	37	74.0	4
6-10people	11	22.0	
11-15people	2	4.0	
Educational status			
Non formal	8	16.0	11.70
Primary	3	6.0	
Secondary	10	20.0	
Tertiary	29	58.0	

Source; Field survey, 2019.

Socio-economic characteristics of respondents

The mean age was 35years.This agrees with the findings of Ezeh (2013) who reported that age range of extension agents is between 40-60 years. Table 1 further revealed that, male respondents accounted for 72% and 28% were female. The involvement of more male as extension workers may probably be due to the cultural and religious belief of the rural people (especially in Northern Nigeria) which tends to restrict women to household domestic chores. The findings also shows that 58% of respondents had attained tertiary level education, 20% had attained secondary level education, while 16% attained non-formal and very few 6% attained primary level education. The level of education of extension agents agrees with the findings of Ezeh (2013) who found out that the majority of extension agents completed post-secondary education.

Table 2: Extension service rendered by the respondent

Extension services rendered	**SA**	**A**	**UD**	**DA**	**SD**	**WS**	**WM**	**Position**
Educating the farmer	33(165)	15(60)	2(6)	0(0)	0(0)	231	4.62	1st
Training farmers on new practices	31(155)	17(68)	1(3)	0(0)	1(1)	227	4.54	2nd
Teach farmers to improve productivity	26(130)	23(92)	1(3)	0(0)	0(0)	225	4.50	3rd
Creating awareness on possible new techniques	25(125)	24(96)	1(3)	0(0)	0(0)	224	4.48	4th
Provision of advisory services	23(115)	27(108)	0(0)	0(0)	0(0)	223	4.46	5th
Promotion of environmentally friendly management methods	26(130)	22(88)	1(3)	1(2)	0(0)	218	4.39	5th

Source; Field survey, 2019 Note SA= Strongly Agree, A=Agree, UD=Undecided, DA= Disagree SD=Strongly Disagree WS= Weighted Sum WM= Weighted Mean Cut-off mean=3.0

Extension service rendered by the respondent

Results on Table 2, shows that services rendered by the extension officers among other are education of farmers ($\bar{X}$= 4.62), Training of farmers on new practices ($\bar{X}$=4.54), teaching farmers to improve productivity ($\bar{X}$=4.50), creating awareness on possible new techniques ($\bar{X}$=4.48), Provision of advisory services ($\bar{X}$=4.46) and promotion of environmentally friendly ($\bar{X}$=4.39).

Table 3: Respondent perceived causes of conflicts

Perceived causes	**SA**	**A**	**UD**	**DA**	**SD**	**WS**	**MS**	**Rank**
Increased pressure on land	35(175)	12(48)	0(0)	2(4)	1(1)	228	4.56	1st
Search for water and pastures	20(100)	22(88)	3(9)	3(6)	2(2)	205	4.1	2nd
Population growth	19(95)	12(48)	11(33)	6(12)	2(2)	198	3.96	3rd
Extortion by community leaders	14(70)	23(92)	6(18)	7(14)	0(0)	194	3.88	4th
Inadequate grazing reserves	16(80)	12(48)	11(33)	11(22)	0(0)	183	3.66	5th
Blocking water sources	7(35)	19(76)	14(42)	7(14)	3(3)	170	3.4	6th

Source; Field survey, 2019. Note SA= Strongly Agree, A=Agree, UD=Undecided, DA= Disagree SD=Strongly Disagree WS= Weighted Sum WM= Weighted Mean Cut-off mean=3.0

Respondent perceived causes of conflicts

The farmer- Pastoralist conflict is one of the most complex social problems affecting Nigeria's survival as it has direct impact on the survival of those involved who the country depend heavily on, in terms of provision food and raw materials for industry and export in order to meet ever-growing demands In the study area, the causes of conflicts are increased pressure on land ($\bar{X}$= 4.56), Search for water and pastures ($\bar{X}$=*4.1*), Population growth ($\bar{X}$=*3.96*). Audu (2013) who opined that about half of the land conflicts are over boundaries that occur mainly with neighbors or relatives who live close by, decrease in water availability as a result of changes in global climatic conditions and migration of herdsmen. In the past five years, it appears that there are more conflicts related to land sales. As the value of land increases due to population pressure, agricultural commercialization, and urbanization, it is expected that the land sales market will develop over time. However, if property rights are not clearly defined, there could be more cases of land conflicts related to land sales.

Table 4: Effect of farmer-pastoralist conflict on Extension service delivery

Effects of conflicts	SA	A	UD	DA	SD	WS	WM	Rank
Extension work becomes difficult	26(130)	21(84)	2(6)	0(0)	1(1)	221	4.42	1st
Completion of extension work are delayed	23(115)	26 (104)	1(3)	0(0)	0(0)	219	4.38	2nd
Monitoring farmers progress becomes difficult	21(105)	27(108)	0(0)	1(2)	1(1)	216	4.32	3rd
Destruction of mutual trust between farmer and pastoralist	29(145)	15(60)	2(6)	3(6)	1(1)	212	4.24	4th
Programme evaluation becomes difficult	17(85)	30(120)	0(0)	2(4)	1(1)	210	4.2	5th
Reduces turnover of extension work	13(65)	32(128)	4(12)	0(0)	1(1)	206	4.06	6th

Source; Field survey, 2019. Note SA= Strongly Agree, A=Agree, UD=Undecided, DA= Disagree SD=Strongly Disagree WS= Weighted Sum WM= Weighted Mean Cut-off mean=3.0

The Effects of Conflicts on Extension Services Delivery

Table 4 shows that conflicts affect extension services delivery ($\bar{X}$=4.42), causes delay in completion of extension work ($\bar{X}$=4.38), difficulty in monitoring farmer ($\bar{X}$=4.32), destruction of mutual trust between farmer and pastoralist ($\bar{X}$=4.24), Programme evaluation becomes difficult($\bar{X}$=4.2), reduce turn-over of extension worker ($\bar{X}$=*4.06*), extension agent abandon work ($\bar{X}$=*3.98*), and hampers cooperative activities(mean=3.96),

Table 5: Socioeconomic loses among respondents as a result of conflict

Variables	Frequency*	Percentages (%)
Loss of lives	20	14.59
Loss of animals	33	24.08
Loss of properties	33	24.08
Migration	13	10.21
Reduction in crop production	37	27.00

Source; Field survey, 2019 *Multiple Responses Recorded

Socioeconomic loses among respondents as a result of conflict

The result shows that 14.49% of the respondents agreed that there was loss of lives during conflict, while 24.08% accepted that there was loss of animals and properties during the conflict. Finding of this study is in line with the studies of Aliyu (2015): Burton (2016). who reported that loss of lives and properties are some of the characteristic features of farmer-herders conflict. Also, Adeoye, (2017) reported that herders-farmers clashes over cattle destruction of crops; farmers' encroachment on grazing reserves and indiscriminate bush burning by nomads usually leads to loss of crops

Table 6: Constraint face by the respondent in delivering extension service in the study area

Constraints	SA	A	UD	DA	SD	WS	WM	Rank
Bad road	23(115)	23(92)	2(6)	2(4)	0(0)	217	4.34	1st
Reoccurrences of conflicts	27(135)	9(36)	8(24)	4(8)	2(2)	205	4.1	2nd
High cost of transportation	14(70)	24(96)	5(15)	5(10)	2(2)	193	3.86	3rd
Inadequate cooperation from community leaders	10(50)	25(100)	2(6)	2(4)	1(1)	161	3.22	4th
Migration and displacement of farmer	0(0)	11(44)	17(51)	2(4)	14(14)	113	2.26	5th

Source; Field survey, 2019. Note SA= Strongly Agree, A=Agree, UD=Undecided, DA= Disagree SD=Strongly Disagree WS= Weighted Sum WM= Weighted Mean Cut-off mean=3.0

RECOMMENDATIONS

- it is recommended that land reforms and laws should be ratified and enforced by key government authorities such as the Parliament, government, judiciary, and local government to ensure peace and prosperity.
- The study recommends that capacity building should be provided to both the farmers and pastoralists by the government officials and NGOs to build relevant infrastructures for rainwater harvesting so that they can use for various purposes (livestock, domestic, irrigation and pasture production).
- Farmers and pastoralists should be given input subsidies in order to use land resources economically.

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EFFECT OF SIRE ON BIOMETRIC CHARACTERISTICS OF JAPANESE QUAILS REARED IN TROPICAL ENVIRONMENT

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ABSTRACT
*The study was conducted to determine the effect of sire on body linear measurement of Japanese quails. Six sires were randomly mated with 4 dams each to generate the quail chicks. The chicks were raised following standard procedure until maturity and data were collected on body weight, breast girth, body, wing and shank lengths. The data collected were subjected to one-way analysis of variance and correlation procedure of the SPSS statistical package. The results obtained indicated that sire had significant effects on shank length and breast girth. Sires 1, 4 and 6 had significantly higher shank length while sire 4 had significantly breast girth compared to other sire groups. The highest coefficient of variability (CV) value was noted in breast girth followed by body length and shank length while the wing length had the lowest CV value. The phenotypic correlation between body weight and body linear measurement were all positive, generally high and significant. Body weight vs shank length demonstrated the strongest (0.861**) relationship. Correlation between wing length and all other body linear parameters were all very low and not significant. From the findings of this study, it was recommended that selection of Japanese quails should be based on individual selection due to significant effect of sire on body linear parameters. Also, the strongest correlation between body weight and shank length couple with high value of coefficient of variability indicated that shank length is the best linear parameters to be used for selection if meaningful progress must be made.*
Keywords: *body linear measurements, Japanese quails, sire, coefficient of variation, phenotypic correlation, Tropical environment.*

INTRODUCTION
Poultry industry is one of the growing industries globally; many people have developed interest and realized the benefits of investing in this area of production (Abdel-Azeem, 2005, Ojo *et al.,* 2011). Globally, due to the continued preference of white meat to red meat, consumption of poultry has increased from 68.5 million tons in 2000 to 103.5 million tons in 2012 which is a 51 per cent increase. This has led to increased animal protein consumption 11.1g per day to 13.6g per day (Abdel-Fatah *et al.*, 2006). In Africa, per person average animal protein consumption is as low as 6g per day. This is far below the Food and Agriculture Organization recommended of 26 g per person per day (Gambo, *et al.,* 2013). The potential of poultry production has not been fully exploited because most farmers have restricted themselves to chicken production as compared to other birds such as quails which are equally of economic, social and nutritional benefits. In spite of intensive research, however, much still remains to be discovered and verified with regard to why there is slow uptake of quail farming by farmers. Quails have several advantages which includes: they mature early, are excellent layers, low feed consumption, require small floor space, have high immunity against diseases, meat low in fat and their eggs are claimed to have high nutritive and medicinal value (Ali *et al.,* 2002; Gambo *et al.,* 2013). Quail rearing at small-scale household level has still potential to open another avenue to provide an alternative source of animal protein and to offer the poor families as an income generation source by rearing a small unit of quails. The general objective of this study is to assess effect of sire on body weight and body linear measurements of Japanese quails.

MATERIALS AND METHODS

The experiment was carried out at the Livestock Teaching and Research Farm of the Faculty of Agriculture, Shabu-Lafia Campus, Nasarawa State University, Keffi, Nasarawa State. Nasarawa State falls within the Southern Guinea Savannah Zone of Nigeria. Lafia lies between latitude 7^0 and 9^0 North and Longitude 7^0 and 10^0 East. It has a climate typical of the tropical zone because of its location. It has a temperature ranging from 20 ^{0}c in October to 36 ^{0}c in March while rainfall varies from 13.73 cm in some places to 14.00 cm in others. The area is characterized by farmers with backyard animal (chicken) rearing (Faculty Weather Station, 2022).

Experimental Birds and Their Management

The total of 30 hens and 12 cocks at three weeks of age were purchased from the poultry unit of the National Veterinary Research Institute, Vom, Plateau State and used as the base population. This base population were housed in the same pen for two weeks for the purpose of acclimatization. At the 6th week of age, they were randomized into 6 breeding cages in the rearing house. A mating ratio of 1:4 (i.e. 1 cock to 4 hens) were used. Each breeding cage had a dimension of 47(length) x 40(width) x 36(height) cm. The hens in each breeding cage were allowed to freely mate the respective cock as from 6 weeks of age. However, fertile eggs for hatching were collected when the birds were 9 weeks of age for higher rates of fertility and hatchability. Eggs were collected and accumulated for five days. The birds were fed standard feed as recommended by Dafwang (2006). Feed and water were provided *ad-libitum.* Eggs were collected twice a day and accumulated for 5 days during which they were held in egg crates under room temperature with good ventilation. The eggs were labeled according to sire. At the end of 5 days of egg collection, the eggs were transported to Zanwa Hatchery, Lafia for hatching. After successful four batches of hatching, a total of 184 chicks were obtained from the base population. The birds were managed using standard procedure until maturity and data collected.

Data collection

Linear Body Measurement: The linear body measurements such as body length, shank length, wing lengths and breast girth were measured at weekly interval for the first 6 weeks using measuring tape.

Experimental Design and Data Analysis

The design of the experiment was a nested or hierarchical design. In other word, random samples of dams were nested within random sample of sire. The data collected were analyzed using descriptive statistics, correlation and analysis of variance procedure of the SPSS software. Were statistical differences exist, Duncan multiple range test was used to separate the means at 5 percent probability using the same software.

RESULTS

The effect of Sire on body weight and body linear measurements of Japanese quails is presented in table 1. Sire had significant ($P<0.05$) effects on shank length and breast girth. Sires 1, 4 and 6 had significantly higher shank length compared to sires 2, 3 and 5. Similarly, Sire 4 had significantly ($P<0.05$) breast girth compared to other sire group. Sire however did not have significant ($P>0.05$) effect on body length, body weight and wing length.

Table 2 present the descriptive statistics of body weight and body linear measurements of Japanese quails. The result showed various degree of variability. The highest coefficient of variability (CV) value was noted in breast girth with the value of 12.82%. This was followed by body length (12.44%) followed by shank length while the wing length had the lowest (9.86%) CV value.

Phenotypic correlation (Table 3) between body weight and body linear measurement were all positive, generally high and significant. Body weight vs shank length demonstrated the strongest (0.861^{**}) relationship. This was followed by body length vs shank length (0.685^{**}). Correlation between wing length and all other parameters were all very low and not significant.

Table 1: Effect of Sire on body weight and body linear measurements of Japanese quails

Trait	Sire 1	Sire 2	Sire 3	Sire 4	Sire 5	Sire 6	LOS
BW	56.43±3.22	56.90±3.11	48.71±2.84	59.02±3.34	55.13±3.31	56.60±4.07	NS
BL	13.76±0.32	14.00±0.31	14.19±0.33	14.19±0.45	13.70±0.30	13.73±0.40	NS
SL	$4.05±0.11^{a}$	$4.00±0.10^{ab}$	$3.66±0.10^{b}$	$4.082±0.11^{a}$	$4.00±0.11^{ab}$	$4.09±0.15^{a}$	*
WL	12.66±0.30	12.82±0.25	11.68±0.30	13.01±0.26	29.73±17.45	12.33±0.36	NS
BG	$8.91±0.21^{ab}$	$8.88±0.18^{ab}$	$7.99±0.30^{b}$	$10.80±1.73^{a}$	$8.69±0.42^{ab}$	$8.70±0.23^{ab}$	*

BW = body weight, BL = Body length, SL = Shank length, WL = wig length, BG = breast girth, LOS = level of significant, NS = not significant, * = significant at 5% probability

Table 2: Descriptive statistics of body weight and body linear measurements of Japanese quails

Parameters	Range	Minimum	Maximum	Mean	SD	Variance	CV
Body weight	41	90	131	103.40	10.62363	112.862	10.27
Body length	6.5	13.5	20	17.16	2.13454	4.556	12.44
Shank length	2	4	6	5.50	0.56614	0.321	10.29
Wing length	5.5	12.5	18	15.49	1.52826	2.336	9.86
Breast girth	6	8	14	11.40	1.79522	3.223	12.82

Table 3: Phenotypic correlation between body weight and body linear measurement of Japanese quails

Parameters	BW	BL	SL	WL	BG
Body weight (BW)	1				
Body length (BL)	0.671**	1			
Shank length (SL)	0.861**	0.685**	1		
Wing length (WL)	0.062	0.007	0.060	1	
Breast girth (BG)	0.313**	0.279**	0.321**	0.011	1

DISCUSSION

The significant effect of sire on body weight and body linear measurements of Japanese quails as observed in this study strongly agree with the report of Adeogun and Adeoye (2004) and Oyetade *et al.* (2011). Values obtained for body weight and body measurements in this study were similar to the report of Adeogun and Adeoye (2004). The varying degree of variability reported in this study agrees with the report of Gambo *et al.*, (2013). The highest coefficient of variability (CV) value was noted in breast girth. This result is in centrally with the report of Adeogun and Adeoye (2004) who reported that, shank length has the highest value of coefficient of variation in Japanese quails. The generally significant, all positive and high correlation coefficient as observed in this study agrees with the findings of Abdel-Fattah *et al.* (2006) and Saatci *et al.* (2002). The mostly significant correlation obtain in this study is similar to the report of Tawefeuk (2001) and Ali *et al.* (2002). Similarly, the positive phenotypic correlation between body weight and shank length strongly agreed with the findings of Adeogun and Adeoye (2004) who reported that, phenotypic correlations of body weight and shank length are positive at all age from 1-6 weeks of age in Japanese quails. Also, the all positive and generally significant relationships between body weight and body linear parameters agree with Adeogun and Adeoye (2004) and Oyetade (2011) who reported all positively and mostly significant ($P<0.05$) relationship between body weight and all linear body measurement at various ages in Japanese quail. This all positive and mostly significant relationships between body weight and body linear parameters indicate that an improvement in body weight could lead to a concomitant improvement in the body linear measurements. Thus any selection programme aimed at improving body weight will lead to corresponding improvement in linear body measurements of the birds.

CONCLUSION

Sire had significant effects on shank length and breast girth. Sires 1, 4 and 6 had significantly higher shank length while sire 4 had significantly breast girth compared to other sire group. The highest coefficient of variability (CV) value was noted in breast girth followed by body length and shank length while the wing length had the lowest CV value. The phenotypic correlation between body weight and body linear measurement were all positive, generally high and significant. Body weight vs shank length demonstrated the strongest (0.861**) relationship. Correlation between wing length and all other body linear parameters were all very low and not significant. From the findings of this study, it was recommended that, selection of Japanese quails should be based on individual selection due to significant effect of sire on body linear parameters. The strongest correlation between body weight and shank length couple with high value of coefficient of variability indicated that shank length is the best linear parameters to be used for selection in Japanese quail.

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EFFECT OF BATCH PER HATCH ON HATCH WEIGHT AND WEEKLY BODY WEIGHT OF FULANI CHICKEN ECOTYPE

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ABSTRACT
Study on the effect of batch of hatch on hatch weight and weekly body weight of Fulani chicken ecotype was undertaken to investigate genetic diversity within the populations. A total of 55 chickens at maturity were purchased and used as the base population. The birds were mated at a ratio of 1 cock to 10 hens and eggs were collected for hatching. After successful four batches of hatching, 184 chicks were generated. The birds were raised according to their batches. Data were collected on hatch weight and body weights. The data collected were subjected to one-way analysis of variance using SPSS statistical software version 21. The results indicate that batch of hatch had significant ($P<0.05$) effect on hatch weight and weekly body weight. Batch 2 had significantly ($P<0.05$) higher hatch weight and body weights at weeks 1 and 2 respectively while at weeks 3, 5, 6 and 10 weeks, birds in batches 3 and 4 had significantly ($P<0.05$) higher body weights compared to those in batches 1 and 2. At weeks 4, 8, 9 and 12, birds in batch 4 had significantly ($P<0.05$) higher body weights compared to batches 1, 2 and 3 while at weeks 7 and 20, birds in batch 3 had significantly ($P<0.05$) higher body weight with values of 209.46±6.71g and 1093.09±34.75g respectively. From this study, it was recommended that the genetic diversity across batch of hatch observed in this study should be exploited through selection and subsequent crossing between birds from different batch of hatch to take advantage of heterosis.

Keyword: *Brooding, day-old-chicks, deep litter, hatching, incubation.*

INTRODUCTION
Genetic diversity is the product of interaction between environment and genetic effects. Quantifying the structure of genetic diversity in chicken populations is of significance in optimizing genetic improvement, conservation and utilization strategies. The unique values of the Fulani chickens' genes for egg and meat production, disease resistance, hardiness and adaptation to local environment would in future be needed to broaden the genetic resource base for breeding of improved commercial birds. Nigerian local chickens have been described based on phenotypic traits by several researchers (Mancha, 2004; Momoh *et al.*, 2007; Desha *et al.*, 2016; Gambo *et al.*, 2023). Such information if complemented with findings obtained using batch of hatch could be useful in formulating long term plans of breeding for genetic improvement programs. The objective of the study was to determine the effect of batch of hatch on growth performance of Fulani chicken ecotype of Nigeria.

MATERIALS AND METHODS
The experiment was carried out at the Livestock Teaching and Research Farm of the Faculty of Agriculture, Shabu-Lafia Campus, Nasarawa State University, Keffi, Nasarawa State. Nasarawa State falls within the Southern Guinea Savannah Zone of Nigeria. Lafia lies between latitude 7^0 and 9^0 North and Longitude 7^0 and 10^0 East. It has a climate typical of the tropical zone because of its location. It has a temperature ranging from 20 ^{0}c in October to 36 ^{0}c in March while rainfall varies from 13.73 cm in some places to 14.00 cm in others. The area is characterized by farmers with backyard animal (chicken) rearing (Faculty weather Station, 2022).

Experimental Procedure
A total of 55 Fulani chicken ecotype comprising 50 hens and 5 cocks were purchases from Fulani settlement and used as the base population to generate the foundation birds. The birds were housed according for two weeks for

quarantining and acclimatization. The birds were randomly assigned into identified five breeding pens in the rearing house. A mating ratio of 1:10 (i.e. 1 cock to 10 hens) was used. The cock in each breeding pen was allowed to freely mate their respective hens. Fertile eggs for hatching were collected when the birds had laid for four weeks. This was aimed at obtaining higher fertility and hatchability. The birds were fed standard feed as recommended by Dafwang (2006). Feed and water were provided *ad-libitum.* Eggs were collected twice a day and accumulated for 5 days during which they were held in egg crates under room temperature with good ventilation. At the end of 5 days of egg collection, the eggs were transported to Phenab Agro Venture, beside fire service, Bukuru express way, Angul-D Jos for hatching. The eggs were set for hatching in an automatic electric incubator at weekly interval for four consecutive weeks (four batches). After successful four batches of hatching, a total 184 chicks were obtained from the base population. The birds were managed using standard procedure until maturity and data collected.

Parameters Measured

Hatch weight and weekly body weight: Live body weights were measured at hatch using sensitive electronic scale and then at weekly interval until 12 weeks of age. Thereafter, body weights were taken at week 16 and week 20.

Experimental Design Data Analysis

The design of the experiment was Completely Randomized Design (CRD). Data collected were analyzed using one-way Analysis of Variance (ANOVA) of the SPSS statistical software (2011) to test the effect of batch of hatch on hatch weight and weekly body weight. The following statistical model was entertained:

$Y_{ij} = \mu + E_i + e_{ij}$

Y_{ijk} = The j^{th} observation on the i^{th} batch of hatch

μ = Overall mean

E_i = Fixed effect of the i^{th} batch of hatch (j = 1, 2, 3 and 4)

e_{ij} = Random residual error ~ (0, 1)

RESULTS

Batch of hatch had significant (P<0.05) effect on hatch weight and weekly body weight of fulani local chickens except on body weight at week 16 which was not significant. Batch 2 had significantly (P<0.05) higher hatch weight and body weights (26.62±0.40 g, 38.80±0.74g and 48.00±1.28 g) at weeks 1 and 2 respectively. At 3, 5, 6 and 10 weeks, birds in batches 3 and 4 had significantly (P<0.05) higher body weights compared to those in batches 1 and 2. Batch 4 had significantly (P<0.05) higher body weights at weeks 4, 8, 9 and 12 compared to batches 1, 2 and 3. At weeks 7 and 20, birds in batch 3 had significantly (P<0.05) higher body weight with values of 209.46±6.71 g and 1093.09±34.75 g, respectively. Birds in batches 2, 3 and 4 had significantly (P>0.05) higher body weight compared to batch 1.

Table 1: Effect of Batch of Hatch on Hatch Weight and Weekly Body Weight (g) of Fulani Chickens Ecotype

Body Weight	Batch 1	Batch 2	Batch 3	Batch 4	LOS
HWT	24.51 ± 0.61^{b}	26.62 ± 0.40^{a}	24.49 ± 0.35^{b}	23.88 ± 0.41^{b}	*
Week 1	34.86 ± 0.76^{bc}	38.80 ± 0.74^{a}	37.00 ± 0.91^{ab}	34.49 ± 0.73^{c}	*
Week 2	45.40 ± 1.16^{ab}	48.00 ± 1.28^{a}	44.28 ± 1.01^{b}	46.11 ± 1.05^{ab}	*
Week 3	52.80 ± 1.65^{b}	55.77 ± 1.45^{ab}	58.52 ± 1.41^{a}	59.94 ± 1.63^{a}	*
Week 4	66.71 ± 2.37^{c}	79.50 ± 2.02^{b}	77.89 ± 2.05^{b}	96.81 ± 2.94^{a}	*
Week 5	95.98 ± 3.99^{b}	94.23 ± 2.40^{b}	128.41 ± 3.96^{a}	127.92 ± 3.90^{a}	*
Week 6	109.63 ± 4.47^{b}	118.25 ± 3.61^{b}	165.68 ± 4.93^{a}	162.72 ± 5.15^{a}	*
Week 7	131.61 ± 4.87^{c}	141.44 ± 4.15^{c}	209.46 ± 6.71^{a}	180.03 ± 6.08^{b}	*
Week 8	163.15 ± 6.14^{d}	183.35 ± 4.94^{c}	228.55 ± 6.86^{b}	284.24 ± 5.44^{a}	*
Week 9	207.61 ± 8.09^{c}	219.76 ± 5.86^{c}	268.74 ± 6.67^{b}	293.82 ± 11.23^{a}	*
Week 10	244.80 ± 8.26^{b}	244.83 ± 6.70^{b}	316.09 ± 8.01^{a}	309.33 ± 8.10^{a}	*
Week 11	277.80 ± 8.86^{b}	372.16 ± 10.50^{a}	369.74 ± 10.64^{a}	368.50 ± 10.19^{a}	*
Week 12	402.35 ± 12.28^{c}	431.20 ± 11.56^{bc}	442.95 ± 13.35^{ab}	474.42 ± 9.49^{a}	*
Week 16	670.26 ± 18.37	694.63 ± 23.42	692.23 ± 30.61	704.37 ± 15.28	NS
Week 20	961.93 ± 30.83^{b}	1004.15 ± 24.22^{b}	1093.09 ± 34.75^{a}	958.30 ± 34.70^{b}	*

HWT = hatch weight, G = gram, LOS = level of significant, ^{abcd} = value with the same superscript on the same row are not significant (P>0.05) different, NS = non significant, * = significant at 5 percent probability.

DISCUSION

The significant effect of batch of hatch on hatch weight and weekly body weight obtained in this study strongly agrees with the report Gambo *et al.,* (2023) who reported that batch of hatch had significant effect on growth parameters of Nigerian Tiv chicken ecotype. The results also agree with the report of Mancha (2004) and Momoh *et al.* (2007) who observed that, differences in live weight in local chicken could varies due to locations, batches, environment, crossbreeding and family level preference, isolation and selection. Also, this result agrees with the report of Desha *et al.* (2016) who reported that batch of hatch had significant effects on body weight of Bangladesh local chicken. The mean body weights across batches of hatch from weeks 1- 8 were lower than the values reported by Gwaza *et al.* (2015). The mean body weight obtained at hatch across batches in this study strongly corroborated with the value of 23±1.60 g reported by Adedokun and Sonaiya (2001) and fall within the range of 22.22g to 43.00g reported by Anang *et al.* (2001) for some local chicken in Nigeria. Momoh (2005) reported 24.27±0.05g and 30.23±0.06g for the Nigerian light and heavy chicken ecotypes. Halima (2007) reported a slightly higher value of 27.30 g as body weight at hatch. Woanski *et al.* (2006) reported that hatch weight is a function of egg weight (size) prior to incubation. These authors opined that, heavier eggs contain more nutrients than small or medium sized eggs and as a result, chicken from heavier eggs tend to have more yolk attachment at hatching. This is expected since there is strong correlation between egg weight and chick hatch weight (Ndofor-Foleng *et al*., 2015). At week 4, the mean body weight in all batches is far lesser than 92±2.10g, 104±14.50g and 157.16±0.45g reported by Momoh (2005) for Nigerian local chicken. However, at week 8, mean body weight obtained in this study across batches of hatch are similar to 262±4.8 and 289±2.2 g reported by Adedokun and Sonaiya (2001) but lower than 349.88±3.01 g reported by Momoh (2005) for Nigerian heavy chicken ecotype. These observed differences could be due to environment, season, management practice, strain and selection among others. The body weight at week 12 is far less than 589±4.4 and 605±67.5 reported by Adedokun and Sonaiya (2001). The body weight at week 16 acros batches is fairly similar to the value of 744±0.01 and 765±103.4 reported by Adedokun and Sonaiya (2001). Body weight at week 20 considered to be matured weights in all batches fall within the range of 980 to 1,420g and 870-1,900g reported by Essien and Joy (2003), respectively for Nigerian local chicken. Mancha (2004) observed 1.38±0.05 kg as matured body weight of local chickens in Jos, Plateau State. At maturity, live weight changes with natural processes, production status, management practices and seasonal changes. Mancha (2004) stated that under similar management and seasons, body weight difference could be due to variation in additive genetic variance. The author also opined that body size differences could occur between populations due to environment, cross breeding and development through progressively family-level selection especially when such populations are isolated. The result of effect of batch of hatch on hatch weight and subsequent weekly body weight demonstrated that weekly hatches in not more than three consecutive hatches can be taken as the same age group. This implies that in rural settings where large numbers of eggs can not be hatched at once due to small flock sizes, chicks from two to three consecutive hatches can be managed together to achieve uniform growth and development. Also, several batches of hatch have revealed several genetic characteristics within the birds which could be utilized for genetic improvement through selection.

CONCLUSION

Batch of hatch had significant (P<0.05) effect on weekly body weight, body weight gain and growth rate at day old and at subsequent weeks until maturity in Fulani ecotypes. However, birds in batch 1 had significantly (P<0.05) higher weekly body weight, body weight gain and growth rate at hatch, weeks 1, and 3 while birds in batches 3 and 4 had significantly (P<0.05) higher body weight from weeks 4-20. In the Tiv ecotype, batches 3 and 4 significantly (P<0.05) differed from batches 1 and 2 at weeks 2-3, 3-4 and 5-6.

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ASSESSMENT OF THE BREEDING OBJECTIVES AND REPRODUCTIVE PERFORMANCE OF FULANI ECOTYPE CHICKENS IN NASARAWA STATE

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ABSTRACT

The present study was conducted to assess the characteristics of Fulani chicken production in Nasarawa South agro-ecological zone of Nasarawa State. A total of 200 female Fulani ecotype chicken farmers (40 per LGA) were randomly sampled in Lafia, Doma, Obi, Keana and Awe. Well-structured questionnaires were administered on the farmers. The questionnaires contained information on the socio-economic characteristics of the respondents, breeding objectives and flock reproductive performance. The categorical variables were compared using Chi square (χ^2) statistics. Descriptive statistics were computed for the continuous variables. The result obtained indicated there were more of married women (95.0%) than single women (5.0%). Most of the farmers had secondary education (37.0%) while 62.0% of the women had no access to financial credit. The mean age of the farmers was 43.29 years while the mean household size was 8.54. The primary reasons why the women keep Fulani chickens were for income. 71.5 % of the respondent said they kept Fulani chickens for income. This was followed by the consumption of eggs (17.0%) and meat (11.5%). The mean clutch number was 5.57 while the number of eggs in a clutch was 11.08. The length (days) of natural incubation per clutch was 21.2 while the mean number of eggs that hatched in a clutch was 8.44. There is a need to boost Fulani chicken production in the study areas through modern breeding practices and interventions from the governments and other donor agencies.
Keywords: *Smallholder, chicken, performance, breeding, Nasarawa State*

INTRODUCTION

The main challenge of developing countries is to ensure food sufficiency and safety for the relatively poor population. These countries have therefore focused their development programmes of food safety and security on livestock production in general and short-cycle species in particular including the traditional poultry breeding systems. Although local chickens are generally less productive when compared to the exotic species, native chickens play an important role as a household food supply in the rural areas of Nigeria (Ogunshola et al., 2012; Yakubu & Ari, 2018; Terfa et al., 2019). They serve as a rapid means of bridging protein deficiency and providing an additional income to the generally resource-poor farmers, thereby helping to alleviate poverty.

The Fulani ecotype is native to the harsh parts of the country, and its purity has been preserved by the isolated family group lifestyle of the Fulani keepers, which hinders its interbreeding with other native chickens (Fayeye et al., 2005). However, they are of small size and lay lesser eggs compared to their exotic counterparts. There is therefore a need to improve these birds. Such improvement effort will be more imperative if it adopts the bottom-top approach while considering farmers' production objectives. This is central to the formulation of livestock breeding policies aimed at improving the livelihoods of smallholder chicken farmers (Yakubu et al., 2020), who raise their chickens mainly in scavenging and semi-intensive systems (Ngogo et al., 2023). In Nasarawa State, north central Nigeria, there is dearth of information on the traditional breeding practices and performance of Fulani ecotype chicken farmers. The objective of this study therefore was to assess the breeding practices and reproductive performance of Fulani ecotype chickens reared by female farmers in Nasarawa South agro-ecological zone of Nasarawa State.

MATERIALS AND METHODS

The study was conducted at Lafia, Doma, Obi, Keana and Awe Local Government Areas (LGAs) of Nasarawa State. The five LGAs fall within Nasarawa South agro-ecological zone of the State. Qualitative-quantitative research design (survey only) was applied in the study. A total of 200 female Fulani ecotype chicken farmers (40 per LGA) were randomly sampled in two villages of Lafia (Wakwa and Gimare), Doma (Dogon Kurmi and Alwaza), Obi (Daddare and Angwan atashi), Keana (Giza and Kadarko) and Awe (Azara and Ribi) local government areas. Well-structured questionnaires were administered on the farmers. The questionnaires contained information on the socio-economic characteristics of the respondents, breeding objectives and reproductive performance of the flock. Female Fulani ecotype chicken' farmers were asked separately to list the reasons why they are into the rearing of Fulani birds in order to assess their production objectives. The categorical variables were compared using Chi square (χ^2) statistics. Descriptive statistics were computed for the continuous variables. IBM-SPSS (2020) statistical package was employed in the analyses.

RESULTS

The socio-economic characteristics of the female farmers rearing Fulani chickens in Nasarawa South are presented in Table 1. There were more of married women (95.0%) than single women (5.0%). Most of the farmers had secondary education (37.0%) while 62.0% of the women had no access to financial credit. The mean age of the farmers was 43.29 years while the mean household size was 8.54.

Table 1. Socio-economic characteristics of the female farmers rearing Fulani chickens in Nasarawa South

Parameters	**Frequency/(%)**	**Chi-square**	**P-value**
Categorical variables			
Marital Status			
Single	10 (5.0)	162.00**	0.01
Married	190 (95.0)		
Educational level			
None	34 (17.0)	27.52**	0.01
Primary	62 (31.0)		
Secondary	74 (37.0)		
Tertiary	30 (15.0)		
Access to credit			
Yes	76 (38.0)	11.52**	0.01
No	124 (62.0)		
Quantitative variables			
Parameters	**Mean**	**Standard Deviation**	
Age (years)	43.29	7.41	
Household size	8.54	5.41	
Market experience (years)	19.75	10.62	

The primary reasons why the women keep Fulani chickens are presented in Table 2. Most of the respondents (71.5%) said they kept Fulani chickens for income. This was followed by the consumption of eggs (17.0%) and meat (11.5%).

Table 2. Reasons for keeping Fulani chickens

Parameters	**Frequency/(%)**	**Chi-square**	**P-value**
Meat	23 (11.5)	132.01**	0.01
Eggs	34 (17.0)		
Income	143 (71.5)		

The productivity indices of Fulani chickens in Nasarawa South are presented in Table 3. The mean clutch number was 5.57 while the number of eggs in a clutch was 11.08. The length (days) of broodiness per clutch was 21.2 while the mean number of eggs that hatched in a clutch was 8.44. The percentage hatchability therefore was 76.2%.

Table 3. Productivity characteristics of Fulani chickens in Nasarawa South

Parameters	Minimum	Maximum	Mean	Standard error
No of clutch of eggs laid in a year	2	7	5.57	0.11
No of eggs in a clutch	3	18	11.08	0.25
Length (days) of broodiness per clutch	19	23	21.21	0.08
No of eggs that hatched in a clutch	2	15	8.44	0.21

DISCUSSION

The characterization of chicken farmers is imperative in order to understand the production environment and performance of the birds. In the present study, the population of married women was more than single. The mean household size of 8.54 also appears high. This is an indication that there will be more hands to assist in the care of the birds. The level of understanding of farmers and the implementation of new technologies requires the analysis of the role of household members and gender in village chicken production (Mujyambere et al., 2022). On the average, the female farmers of this study appear to be literate. The implication of this is that they will be more disposed to adopting better management practices and innovations to boost production. Poor access to financial credit could hamper the production level of the farmers. The mean age (43.29 years) of the farmers implies that they are still very active. Income was found as the primary reason for keeping chicken in the study area. This is not surprising considering the importance of money in meeting the financial needs of the households. According to Alabi et al. (2007), family poultry husbandry has the potential to influence women income. The present findings are also consistent with the submissions of Yakubu et al. (2020) and Ogunwale et al. (2021). In terms of productivity indices, the average values observed for Fulani chickens with regard to mean clutch number, the number of eggs in a clutch, the length (days) of broodiness and the mean number of eggs that hatched appear to be within the limits expected of traditionally managed birds in Nigeria (Sola-Ojo et al., 2011). The hatchability rate of 76.2% obtained in the current study is close to the range of 78.6-85.8% reported by Mengesha et al. (2022) in Ethiopian indigenous chickens. Notwithstanding, the performance of the Fulani birds,they may be improved when crossed with other certified dual-purpose tropically adapted birds. The genetic superiority of improved tropically adapted birds over the locals has been reported in earlier studies (Ajayi et al., 2020; Akinsola et al., 2021). Also, crossbred chickens have been found to exhibit hybrid vigour in terms of egg production under free range and semi-intensive systems under tropical conditions (Ochora *et al.,* 2023).

CONCLUSION

In the present study, the population of married women was more than those that were single. The mean household size appears high while the female farmers were within the active growth age, which implies that there will be enough labour to assist in the care of the birds. A good number of the farmers were literate which could assist in better management decisions and adoption of innovative techniques to boost production. Majority of the farmers did not have access to financial credit. The primary reason for keeping the Fulani birds was to generate income. The average values observed as regards mean clutch number, the number of eggs in a clutch, the length (days) of broodiness and the mean number of eggs that hatched are pointers to the fact the rearing Fulani chickens could be profitable. However, future studies are advocated to evaluate performance when Fulani chickens are crossed with superior tropically adapted birds.

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ANALYSIS OF PROFITABILITY OF BROILER PRODUCTION IN JOS NORTH LOCAL GOVERNMENT AREA OF PLATEAU STATE, NIGERIA.

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ABSTRACT

The study on the analysis of profitability of broiler production was carried out in Jos North Local Government Area of Plateau State, Nigeria. The specific objectives were to: describe socio-economic characteristics and determine the costs and returns of broiler farmers in the study area. Primary data were collected from broiler farmers using structured questionnaire and the study was carried out between July and October 2022. A multi-stage sampling technique was employed to select 107 farmers from which input-output data were collected. Descriptive statistics and net farm income model were employed for data analysis. Descriptive statistics result revealed that about 60% of the respondents fall within the age range of 31 to 50 years with mean age of 39 years, majority of the farmers (90.7%) had formal education. Results also indicated that majority of the farmers (about 71%) had farming experience ranges from 11 to 20 years with mean of 15.83 years. Findings further revealed that the average rate of return on investment (return per naira invested) was ₦1.69 indicating that for every one naira invested in broiler production in the study area, a profit of ₦1.69 was made. It therefore implies that broiler production in the study area was economically viable.

Keywords: *Profitability, Broiler, Plateau State*

INTRODUCTION

Broilers are simply chicken raised for meat and it production is the process of rearing broiler birds for meat, a key measure of performance being the feed conversion ratio (FCR) (Ettah *et al.,* (2021). According to Mgbakor and Nzeadachie (2013) broiler production of the poultry enterprise has great potentials for increasing protein supply in Nigeria, because of their fast growth rates and prolificacy, which can be adapted under a wide range of marginal climatic conditions and can generally be combined conveniently with other farm enterprises and/or occupation, with mutual benefits to the farmer.

MATERIAL AND METHODS

Study Area

The study was carried out in Jos North Local Government Area of Plateau State. Jos North is one of the 17 Local Government Areas in Plateau State. The L. G. A. is situated in the tropical zone lying between latitude 9^0 5 and 11^0 15^1N of the equator and longitude 8^0 5 53' and 90 45^1E of the Greenwich meridian. It is bordered in the northeast by Toro L.G.A. in Bauchi State, the South by Fabur and Shere districts of Jos East L.G.A., on the south by Du and Gyel districts and west by Pengana Irigwe and Rukuba chiefdoms in Bassa L.G.A. of Plateau State, Nigeria (Bitti *et al*., 2020). It has total land area of about 291km^2 with a population of 429,300 National Population Commission (NPC), (2006), with a projected population of 643,200 as at 2022.

Sampling Procedure

A multistage sampling technique was used to select respondent for the study. In the first stage, Jos North Local Government Area was purposively selected due to the prevalence of poultry farmers in the area. Jos north has a total number of 22 villages, and10 villages was selected randomly from the 22 villages. The Final stage involved a proportional sampling of broiler farmers from the 10 villages selected. Sixty-one percent (61%) of the sample frame (176) was used as sample size. A total of 107 farmers were proportionally selected.

Table 1: Sample frame and sample size of broiler farmers in the study area

Villages	Sampling Frame (SF)	Sample size (61% of SF)
T/wada	11	7
Laranto	15	9
Babale	16	10
Naraguta B	17	10
Naraguta A	50	31
Jos Jarawa	10	6
Nassarawa	26	16
Rusau	13	8
Gwash	10	6
Zakaliyo	8	8
Total	176	107

Source: Field Survey: 2022

Data Collection and Analysis

Primary data were used for this study. These were collected with the aid of structured questionnaire, using interview method. The information was collected on farmers' socio-economic characteristics and inputs used like feed, medication, day-old-chicks, and labour. Information was also collected on the output from broiler production. The data were analyzed by means of descriptive statistics which involved the use of percentages and means and Net Farm Income (NFI). The formular for net farm income is stated as follows:

NFI = TR – TC

Where, NFI = net farm income (₦) per 200 birds

TR = total revenue (₦)

TC = total cost of production (₦)

TC = TVC + TFC

TVC = total variable cost

TFC = total fixed cost.

The fixed inputs are not normally used up in a production cycle. They were depreciated using the straight-line method given by:

$D = \frac{P-s}{N}$

Where:

D = Depreciation (₦)

P = purchase value (₦)

S = salvage value (₦)

N = life span of asset (years)

Return per naira invested (RNI) was obtained by dividing the total revenue (TR) over the total cost (TC).

Therefore, $RNI = \frac{TR}{TC}$

Where, RNI = return per naira investment

TR = total revenue

TC = total cost

Decision Rule:

RNI > 1, it implies there is profit in production.

RNI = 1, the farmer is at breakeven

RNI < 1, the farmer is at loss.

RESULTS AND DISCUSSION

Socioeconomic characteristics of poultry farmers

Summary statistics of the findings reported in Table 1 indicate mean age of 39 years for broiler farmers in the study area. This implies that majority of farmers were middle aged and there is likelihood of increased efficiency in broiler production. Also, farmers within the age category of 31-50 constituted most broiler farmers with about 60% indicating that broiler farming in the study area was dominated by an agile workforce that could handle the stress involve in broiler production to increase their efficiency. The findings agreed with Ogheneruemu and Dominic, (2020). Also, about 91% of the broiler farmers had one form of education or the other while about 10% had no formal education. Education could affect their chances of using improved breeds which can boost broiler output. About 71% of the farmers in the study area had farming experience of 11-20 years with mean of 15.83 years. Years of farming experience according to Oladimeji & Abdulsalam, (2013) is a factor that enhances agricultural productivity among farming households in Nigeria.

Table 2: socio-economic characteristics of the respondents

Variables	Frequency	Percentage
Age of broiler farmers (years)		
21-30	24	22.43
31-40	39	36.45
41-50	25	23.36
>50	19	17.75
Total	107	100
Mean = 39		
Educational level		
No formal education	10	9.35
Primary education	12	11.21
Secondary education	45	42.06
Tertiary education	40	37.38
Total	107	100
Farming experience (years)		
1-5	15	14.02
6-10	17	15.89
11-15	29	27.10
16-20	46	42.99
Total	107	100
Mean = 16		

Source: Field Survey, 2022

Average costs and Returns in Broiler Production

Results presented in table 3 shows that the total revenue realized from broiler production in one production season was ₦792,000.94. The result from total variable and fixed costs was ₦411,607.75 and ₦57,940.53 respectively. This implied that broiler business made a net farm income of ₦322,452.26. It therefore means that broiler farmers in the study area made profit. The return per naira invested was 1.69, indicating that for every ₦1 invested in broiler production, a profit of ₦1.69 was made. Thus, it could be concluded that broiler production in the study area was economically viable. This finding is the same with Ettah *et al*., (2021) who observed that broiler production is profitable by returning 1.67 to every ₦1.00 spent.

Table 3: Average Cost and Returns of Broiler Production Per Production Period of 8 weeks (Production Size of 200 Broilers)

Parameters	**Amount (₦)**	**% Contribution**
Fixed Cost		
Building or cage	49,420.33	10.53
Equipment	8,520.20	1.81
Total fixed cost (TFC)	**57,940.53**	
Variable cost		
Day old chicks	92,000.53	19.59
Feeds	280,000.22	59.63

Drugs/vaccines	22,100.11	4.71
Labour	14,316.23	3.05
Electricity/charcoal	2,240.41	0.48
Wood shaving	950.25	0.20
Total variable cost (TVC)	**411,607.75**	
Total cost (TC)	**469,548.28**	
Revenue		
Sales of broiler	780,000.71	
Manure	12,000.23	
Total revenue	792,000.94	
NFI (TR-TC)	322,452.26	
Return per naira invested (TR/TC)	**1.69**	**100**

RECOMMENDATIONS

The results from the study revealed that broiler production in the study area is profitable. Therefore, more youth should be advised to go into broiler production which will provide more job opportunities for the teeming population that are unemployed as well as bridge the gap of protein shortage in Nigeria.

CONCLUSION

Based on the findings of this study, it can be concluded that broiler production in the study area is profitable by returning ₦1.69k to every ₦1.00 invested. Given that broiler is an important source of protein in Plateau state, and Nigeria in general any attempt to increase its productivity would be a right step towards the resolution of food crisis and would also increase the country's Gross Domestic Product (GDP).

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ASSESSMENT OF CONSUMER BEHAVIOR IN PURCHASING RICE IN MINNA METROPOLIS OF NIGER STATE, NIGERIA

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ABSTRACT

The study examined the purchasing behavior of rice consumers in Minna Metropolis of Niger state, Nigeria. Data were collected from 114 rice consumers across markets within the metropolis and this was done to understand the consumer preferences for rice variety for desired attributes. The study used descriptive statistics such as mean, frequency, percentages and Kendall coefficient of concordance. The result shows that a significant proportion 36.84% had their tertiary education and 10.14% had no formal education. A sizeable proportion of the respondents however had secondary and post-secondary education. It was also shown that larger proportions (78.95%) of the sampled heads of households were civil servants and this is not unconnected to the high educational attainment of majority of the household heads. The results of the study show that majority (55.3%) of the respondents consumed rice 2 to 4 times a week whiles 36.6% consumed rice every day and 8.1% of the respondents consumed rice at least once in a week. It also shows that (35%) of the respondents preferred combination of both imported and local rice, whiles 34.1% of the respondents preferred local and 30.9% preferred imported rice. A total of 68.4% of the respondents preferred to purchase rice from the open market, 26.3% (supermarket and 5.3% (shop/store). It was also shown that rice impurities (present of other materials) was the highest ranked constraint by consumers in the study area with the mean rank of 3.42 and followed by high cost of local rice with the mean of 3.90. Inferior taste and poor cohesion were ranked least constraints associated with local rice consumption in the study area with the mean rank of 6.04 and 6.84 respectively. It was concluded that private sector should invest in modern processing facilities for local rice as this would place the commodity in a better position when compared with imported rice. Therefore, it is recommended that knowing what is important about attributes affecting retail outlet selection, marketers should ensure that they meet their customers' expectations concerning those features, and help them gain a competitive advantage.

Keywords: *Assessment, Purchasing Behavior, Rice consumers Niger state and Nigeria*

INTRODUCTION

Rice is an important food crop and major normal food for up to half of the world's population (Dauda *et al*. 2019). It is also the staple food in most African countries, providing dietary energy to the rapid increasing population (Dauda *et al*. 2019). In Africa, rice provides 715 kcal, 27% of nutritional supply of energy, 20% of nutritional protein and 3% of nutritional fat (Dauda *et al*. 2019). Rice occupied fifth major source of energy in diet for mankind, providing 9% of caloric usage (FAO, 2012). Rice is a source of raw material for industries and offers job opportunity for the growing Nigerian population of different forms, from the onset of rice cultivation,

processing, wholesales and sales to final consumers (Marlia *et al*. 2011). Local rice is all rice, regardless of improved or unimproved varieties that are produced within Nigeria.
Consumers often express their preferences for product quality by paying a premium for the product with the desired characteristics. These premiums give producers an incentive to improve product quality and quantity consequently enhancing the welfare of the consumer and the producer. Consumers face tradeoffs in their purchasing decisions since income is limiting and choices are numerous (Lawal *et al,* 2016). The objectives of the study were to describe the socio-economic characteristics of rice consumers; describe purchasing behavior of consumers and describe the constraints associated with the consumption of local rice.

METHODOLOGY

Study Area

The study was undertaken in Minna Metropolis of Niger State, Nigeria. Niger State is located between Latitudes 80 22/N and 110 30/N and Longitudes 30 30/ E and 70 20/ E. The State is bordered by Zamfara and Kebbi States in the North and North-west respectively, currently, the State covers a total land area of 74.244 sq.km, which is about 8% of Nigeria's total land area. This makes the State the largest in the Country (www.nigerstate.gov.ng). The population of the State is about 3,950,249, comprising 2,082,725 males and 1,867,524 females (National Population Commission (NPC, 2006). The projected population of the State as at 2016 was 5,556,200 (United Nations Population Fund (UNFPA), 2016).

Sampling Procedure

A multi-stage sampling technique was used. The first stage was purposive selection of Niger state from North-central zones of Northern Nigeria, and the selection was based on the high concentration and intensity of rice production, processing and marketing within the State. The second stage was purposive selection of three different retail market outlets within the metropolis, selected markets were Kure ultra-model market, Gwari market and Gwadabe market.
In the third stage, based on the reconnaissance survey conducted from all the markets, a total number of 127 rice retailers were identified across the three markets within the metropolis and 40% of the retailers from each market were randomly selected. Estimated average daily number of consumers per retailer was given out by the respective retailers from which 20% were randomly selected. The random selection was systematic so as the researcher selected each 3rd consumer met at retail outlet until reaching the total desired sample size of 114 across the markets within the metropolis.

Method of Data Collection

Primary data was used for the study. The data was collected using a well-structured questionnaire administered to the respondents by the researcher through multi stage sampling techniques. Information on the socio-economic characteristics of the consumers such as age, gender, marital status, farm size, level of education, average income per month, purchasing behavior of consumers and the constraints associated with the consumption of local rice in the study area were collected.

Analytical Techniques

The analytical tools used were descriptive statistics such as mean, frequency, percentages and Kendall coefficient of concordance

RESULTS AND DISCUSSION

Socioeconomic Characteristic of Consumers in the Study Area

The descriptive statistics of socio-economic characteristics such as age, household size, monthly income, gender, marital status, educational level and occupation of household head as shown in Table 1

Table 1: Distribution of rice consumers according to their socio-economic variables (Quantitative)

Variable	Frequency	Percentages (%)
Age		
25-32	6	5.3
33-40	46	40.4
41-48	46	40.4
49- 56	16	14
57-64	-	
Minimum	25	
Maximum	58	

Mean	42	
Standard Deviation	7	
Household size		
1-3	26	22.8
4-7	76	66.7
8-11	9	7.9
12-15	3	2.6
16-19	-	
Minimum	2	
Maximum	18	
Mean	6	
Standard Deviation	3	
Monthly Income (₦)		
15,000-55,000	1	9
56,000-97,000	14	12.3
98,000139,000	37	32.5
140,000-181,000	20	17.5
182,000 -250,000	42	36.8
Minimum	15,000	
Maximum	250,000	
Mean	77,059	
Standard Deviation	42,113	

Source: Field Study, 2022.

Results from table 1 shows the average age of the respondents indicates 42 years with minimum of 25 years and maximum of 58years, which means that most of the respondents ware within the working age group and they are likely to have some disposable income for household expenditure. This indicates that they are young and within the middle age range, capable of making their own decisions on the rice brands they consume. The results of the study revealed that the mean household size as indicated in table 1 was 6 persons per household with the minimum household member of 2 and the maximum household members of 18 persons. Income dictates to a large extent the consumers choice of goods. A rational consumer will make a right choice of superior and high-quality goods as income increases. The result also shows that average monthly household income was estimated to be ₦77, 059 with the minimum ₦15, 000 and maximum of ₦250,000.

Table 2: Distribution of rice consumers according to their socio-economic variables (Qualitative)

Variable	Frequency	Percentages (%)
Gender		
Male	102	89.47
Female	12	10.53
Marital status		

Single	2	1.75
Married	111	97.37
Widow	1	0.88
Divorced		
Level of Education		
No formal Education	15	10.14
Primary education	23	20.17
Secondary education	34	29.82
Tertiary education	42	36.84
Occupation		
Farming	5	7.02
Trading	8	7.02
Civil servant	90	78.95
Artisan	11	9.65
Total	114	100

Source: Field Study, 2022

The result in Table 2 shows that the sampled consumers in the study areas are largely male headed households with 89.47% while 10.53% are female. This finding corroborates the finding of Erhabor and Ojogho (2011), who also found out in a similar study that rice consuming households are largely male headed with 89.3% of the household heads being males. Gender of household head could influence food consumption pattern of households and this was shown by Agbola (2003), who noted that gender was one of the socioeconomic characteristics that was significant in influencing grains, dairy products and vegetables demand in a study on estimation of food demand pattern in South Africa. The distribution of consumers based on marital status as indicated in the table shows that 97.37% ware married, 1.75% ware single and 0.88% ware widow. The level of education of household head has a serious implication for the types and quality of food consumed by the household. The result shows that a significant proportion (36.84%) had their tertiary education and 10.14% had no formal education. A sizeable proportion of the respondents however had secondary and post-secondary education. Educational status of household heads could influence rice demand as well as the preference for imported or local rice types. As noted by Chiwuzulum *et al*.(2010), rice demand was significantly influenced by educational level of households heads on household food demand. The mean years of schooling of the household heads was reported to be 13 years and this is higher than the national mean years of schooling of 5 years for Nigeria (UNDP, 2012).
It was also shown that larger proportion (78.95%) of the sampled heads of households were civil servants and this is not unconnected to the high educational attainment of majority of the household heads. This result suggests that there is a greater tendency for the households to rely on purchasing rice for household consumption rather than own production. This finding is in line with that of Kassali *et al*. (2010), who reported that majority (55 %) of the household heads were civil servants in a study of demand for rice in Osun state.

Purchasing behavior of rice consumers in the study area

Table 3 shows the purchasing behavior of rice consumers in the study area. he results show that majority (55.3%) of the respondents consumed rice 2 to 4 times in a week whiles 36.6% consumed rice every day and 8.1% of the respondents consumed rice at least once in a week. It also shows that 35% of the respondents preferred combination of both imported and local rice, whiles 34.1% of the respondents preferred local and 30.9% preferred imported rice. In a similar study Diako *et al.*, (2010) reported that consumers who patronize domestic rice do so out of preference, perceived good nutritional qualities and relatively low price. A total of 68.4% of the respondents preferred to purchase rice from the open market, (26.3%) supermarket and shop/store (5.3%).

Table 3: Purchasing behavior of rice consumers in the study Area

Variable	Frequency (114)	Percent (%)
Frequency of eating rice		
Once a week	5	4.4
2-4 times a week	63	55.3
Everyday	46	40.4
Type of rice		
Imported rice	8	7.0
Local rice	76	66.7
Both import& local rice	30	26.3
Type of markets		
Open market	78	68.4
Super market	30	26.3
Shop or stores	6	5.3
Total	**114**	**100**

Constraints Associated with *Low Consumption of Local Rice in Minna Metropolis*

*T*he results of *K*endall's *W* are presented in *t*able 4, *where* value of *W* (0.166) was highly significant at 1% significance level, and implies a high level of agreement among the respondents in ranking the constraints associated with local rice consumption in the area.

Results shows that rice impurities (present of other materials) was the highest ranked constraint by consumers in the study area with the mean rank of 3.42 followed by high cost of local rice with the mean of 3.90. Inferior taste and poor cohesion were ranked least constraints associated with local rice consumption in the study area with the mean rank of 6.04 and 6.84 respectively .

Table 4: Constraints associated with local rice consumption in Minna

Constraints associated with local rice consumption	Mean score	Rank
Impurities	3.42	1st
High cost of local rice	3.90	2nd
Poor aroma	4.08	3rd
Less available	4.87	4th
Low swelling capacity	4.89	5th
Broken grains	5.00	6th
Poor packaging	5.96	7th
Inferior taste	6.04	8th
Poor cohesion	6.84	9th

N=114, Kendall's W=0.166, Chi-Square=151.730, Sig. <0.001

CONCLUSION AND RECOMMENDATIONS

The objectives of the study were to describe the socio-economic characteristics of rice consumers; describe purchasing behavior of consumers and describe the constraints associated with the consumption of local rice". The study therefore, recommends that efforts should be made by the government to formulate price control policy on local rice for its affordability by the consumers. Also, farmers should be encouraged to produce more local rice through the provision of incentives and credit facilities for its availability of all year round to the consumers.

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HAEMATOLOGICAL EVALUATION AND ECONOMICS OF PRODUCTION OF BROILER CHICKENS FED DIFFERENT LEVELS OF WHITE SORGHUM AS A REPLACEMENT FOR WHITE MAIZE

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ABSTRACT
The experiment was conducted to evaluate blood parameters and economics of production of broiler chickens fed local white sorghum (farfara) as a replacement for white maize. A total of two hundred and forty day old chicks were used for this study. Five diets for both starter and finisher phase were formulated and were designated as D1, D2, D3, D4 and D5 in which local white sorghum (farfara) replaced white maize at 0%, 25%, 50%, 75% and 100% respectively. Each diet was replicated four (4) times with 12 birds per replicate in a completely randomized design. Feed and water were supplied ad libitum and the experiment lasted for 7 weeks. The result revealed no significant difference in all the parameters measured. It was concluded that local white sorghum (farfara) can replace white maize in broiler chicken diets without adverse effect on performance, blood parameter and economics of production.
Keywords: *Blood Parameters, Replacement, White Sorghum, Economics of Production, Broiler*

INTRODUCTION
Traditionally, maize is used as an energy source in poultry feeds (Rajaesh, 2021). The major challenge in poultry feed production is the shortage of energy feedstuff (maize). It is therefore essential to identify alternative energy feedstuff for profitable and sustainable poultry production. There are various sources of energy in poultry diets in the tropics but maize has remained the chief energy source in compounded diet and constitutes about 50% of poultry ration (Ragab, 2001 and Ajaj *et al.,* 2005). The use of sorghum for human consumption is relatively low compared to maize and is a good alternative source of energy in livestock feeding (Olomu, 2011). According to Atteh *et al.* (1993) such alternatives should have comparative nutritive value but cheaper than maize. They should also be available in large quantities. According to Gebeyew *et al.* (2015), it is important to assess the feeding and replacement value of sorghum for maize as alternative cheap and easily available feedstuffs in broiler ration. Sorghum has a similar energy value to maize therefore sorghum can be used as an energy source in broiler feed (Hidayat *et al.,* 2022). This research was conducted to evaluate blood parameters and economics of production of broiler chickens fed local white sorghum (f*arfar*a) as a replacement for white maize.

MATERIALS AND METHODS
Study Area
The experiment was conducted at the Poultry Units of Teaching and Research Farm of Animal Production Department in Abubakar Tafawa Balewa University Bauchi, Bauchi State. The research began on 15th May, 2022 and ended on 7th July, 2022. Bauchi lies between longitude 10 $^{0}10^{1}$to 30^{1}N and latitude 9041 and 10^{0} 31^{1}E at an altitude of 6902 meters above sea level (BSADP, 1994).

Sources of Experimental Ingredients
White maize, white sorghum, soybean meal and other feed ingredients such as premix, fish meal, lysine, methionine, limestone were purchased from local market in Bauchi metropolis, Bauchi local Government Area - Bauchi State.

Experimental Birds and their Management
A total of 240 unsexed day-old broiler chicks were used for the study. Prior to the arrival of the chicks the brooding room was thoroughly cleaned and disinfected. The floor of the poultry pen was well insulated with a thick layer

of wood shavings and papers were laid to prevent the broiler chicks from swallowing particles of the wood shavings and blinded by dust. On arrival, the broiler chicks were immediately taken into the brooding room which was heated with charcoal to provide warmth for brooding. They were immediately served water containing glucose as anti – stress. Feeds and clean water were supplied *ad libitum*. The chicks were brooded and fed commercial broiler starter for a period of one week. At the end of one week of brooding, the birds were weighed and randomly allotted to five diets which were formulated and designated as diets 1, 2, 3, 4, and 5. Diet 1 was the control (0 % white sorghum), while diets 2, 3, 4 and 5 contain white sorghum as replacement for white maize at 25, 50, 70 and 100% level of inclusion respectively. The formulated diets contained 23% and 20% crude protein in starter and finisher phases respectively. The fixed ingredients included fish meal, bone meal, salt, premix, lysine, methionine, wheat offal and soybean meal (Tables 1 and 2). Each treatment was replicated four times with 12 birds per replicate in a completely randomized design . Feed and water were served *ad libitum*.
All necessary routine management practices such as vaccinations were adhered to throughout the study period. The experiment lasted for a period of 56days (7day brooding, 28days starter and 21 days finisher). Vaccination routine was carried out at 2nd week (Lasota 1st dose), 3rd week (Gumboro) and 5th week (Lasota 2nd dose).

Table 1: Composition of Experimental Diets at Starter phase (2- 5 weeks)

Ingredients	D1 (0%)	D2 (25%)	D3 (50%)	D4 (75%)	D5 (100%)
White maize	50.64	37.98	25.32	12.66	0.00
White sorghum	0.00	12.60	25.32	37.98	50.64
Soybean meal	30.66	30.66	30.66	30.66	30.66
Wheat offal	10.00	10.00	10.00	10.00	10.00
Fish meal	5.00	5.00	5.00	5.00	5.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Lime stone	1.00	1.00	1.00	1.00	1.00
Lysine	0.10	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10	0.10
Salt	0.25	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100
Calculated Analysis (%)					
Metabolisable Energy (Kcal/kg)	2808.48	2791.77	2775.06	2758.35	2743.29
Crude fibre (%)	3.91	3.91	3.91	3.91	3.91
Calcium (%)	0.31	0.39	0.39	0.39	0.39
Phosphorus (%)	0.41	0.44	0.47	0.49	0.53
Lysine (%)	1.30	1.31	1.33	1.34	1.35
Methionine (%)	0.39	0.38	0.37	0.36	0.35

Table 2: Composition of Experimental Diets at Finisher phase (5-7 weeks)

Ingredients	D1 (0%)	D2 (25%)	D3 (50%)	D4 (75%)	D5 (100%)
White maize	54.95	41.21	27.47	13.74	0.00
White sorghum	0.00	13.74	27.47	41.21	54.95
Soybean meal	25.15	25.15	25.15	25.15	25.15
Wheat offal	12.00	12.00	12.00	12.00	12.00
Fish meal	3.00	3.00	3.00	3.00	3.00
Bone meal	2.50	2.50	2.50	2.50	2.50
Lime stone	1.50	1.50	1.50	1.50	1.50
Salt	0.25	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20	0.20
Premix	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100
Calculated Analysis (%)					
Metabolisable Energy (Kcal/kg)	2804.71	2786.58	2768.11	2750.32	2732.18

Crude protein (%)	20.00	20.00	20.00	20.00	20.00
Crude fibre (%)	3.78	3.78	3.78	3.78	3.78
Calcium (%)	0.25	0.25	0.25	0.26	0.27
Phosphorus (%)	0.33	0.36	0.39	0.42	0.45
lysine (%)	1.08	1.09	1.11	1.13	1.12
Methionine	0.33	0.32	0.31	0.29	0.29

Blood Sample Collection for Biochemical and Haematological Parameter

Samples were taken from two birds per replicate through the wing vein with the aid of needle and syringe. Blood sample for haematological parameters were collected into tubes containing EDTA (Ethylenediaminetetraacetic acid) as anti-coagulant. Blood samples for biochemical measurements were collected into sterilized EDTA – free sample bottles to allow the blood to clot for serum separation.

Economic Analysis

The economy of broiler chicken production fed experimental diets was calculated based on the price of the ingredients as at the time of the experiment. The total feed intake (kg) per bird during the 7 weeks of the experimental period was determined by multiplying the overall daily feed intake by number of days the experiment lasted and divided by 1000.

$$\text{Total feed intake} = \frac{DFI_O \times 49 \text{ days}}{1000}$$

Where DFIo is daily feed intake overall; The costs of feeding one bird per treatment for 7 weeks were determined by multiplying the price of each ingredient with the quantity (kg) of that ingredient for the different experimental diets and divided by 25kg. The total weight gain (kg) was determined by multiplying the overall daily weight gain by the number of days the experiment lasted.

$$\text{Total weight gain} = \frac{DWGo \times 49day}{1000}$$

Where DWGo is daily weight gain overall. The total feed cost (₦) was determined by total feed intake (kg) multiply by feed cost (₦). The feed cost per kg weight gain (₦) was determined by dividing total feed cost (₦) with total weight gain (kg).

RESULTS AND DISCUSSION

Serum Biochemical and Haematology Parameters of Broiler Chickens Fed Different levels of White Sorghum (*farfara*) as Replacement for White Maize

Serum biochemistry and haematology of broiler chickens fed graded levels white sorghum (*farfara*) as replacement for white maize. The results of this study elucidated that there was no significant differences (P>0.05) among all the haematological parameters and serum biochemistry (Tables 3 and 4).

Table 3: Serum biochemical parameters of broiler chickens fed graded levels of white sorghum (*farfara*) as a replacement for white maize.

Parameters	Diets					
	1	2	3	4	5	SEM
Total protein (g/dL)	7.18	7.33	7.50	6.63	7.30	0.37 NS
Total cholesterol (mmol/L)	4.86	4.99	5.28	5.32	5.08	0.21 NS
Albumin (g/dL)	3.16	3.38	3.05	3.40	3.23	0.31 NS
Random (mmol/L)	4.30	4.58	5.83	5.51	5.73	0.67 NS

NS= Not significant, SEM= Standard error of the mean.

Table 4: Haematological values of broiler chickens fed white sorghum (*farfara*) as a replacement for white maize.

Parameters	Diets					
	1	2	3	4	5	SEM
PCV (%)	31.30	33.15	29.83	32.70	32.38	2.14 NS
Hb (g/dL)	10.42	11.05	9.93	10.90	10.78	0.71 NS
MCV(FL)	148.98	146.25	144.15	141.32	146.13	3.57 NS
MCHC(g/dL)	42.75	41.45	43.65	40.08	137.05	41.28NS
MCH (pg)	67.78	60.95	64.85	65.78	63.73	3.52 NS

NS= Not significant, PCV= packed cells volume, Hb= Haemoglobin, mean corpuscular volume, MCHC= Mean corpuscular Haemoglobin concentration MCH=Mean corpuscular Haemoglobin.

The serum biochemistry indices observed included total protein which ranged from 6.63-7.18g/dl, these values were higher than 2.00– 3.5 g/dL reported by Banerjee (2018) and Medugu *et al.* (2010) obtained a higher (16.00-34.00g/dL) total protein value. Albumin ranged from 3.16-3.40g/dL to 4.30-5.83mmol/L. The value of albumin from this study was lower (4.30-5.83mmol/L.) than what was reported by Medegu *et al*. (2010) and Lakurbe *et al*. (2020). The non-significant in the values of total protein and albumin elucidates the adequacy of protein in the experimental diets and were efficiently utilized by the birds. It also elucidates that the birds were of good health condition because total protein and albumin are used to measure the biosynthetic function of the liver as it is the primary site for the synthesis of plasma proteins (Hoferberge and Block 1996). Packed cell volume (PCV) ranged from 29.83-33.15%. These values were higher than 20.00-31.67% reported by Medugu *et al*. (2010) but lower than 32.15 – 39.88% as reported by Lakurbe *et al.* (2020). The PCV gotten from this study were within the normal range of 25.00-45.00% as reported by Opoola *et al*. (2013) indicating that the birds were nourished, not anaemic and absence of toxic in white sorghum. Haemoglobin values ranged from 9.93 -10.78g/dl. These values were higher than 4.07-6.83g/dL reported by Medugu *et al*. (2010) comparable with 10.20- 10.90g/dL as reported by Lakurbe *et al.* (2020). Haemoglobin values obtained from this study are within the normal range of 7.00 – 13g/dL for Haemoglobin concentration in broiler chickens as reported by Opoola *et al.* (2013) indicating no obvious detrimental effect of white sorghum on broiler chickens. The values of haemoglobin obtained in this study were similar to 9.90-11.50g/dL obtained by Onabanjo *et al*. (2021). Mean corpuscular volume (MCV) ranged from 141.32-148-98fl. This values are higher than 97.13-119.20fl reported by Medugu *et al.* (2010) but comparable with 148.55-159.75fl obtained by Lakurbe *et al.*(2020). Mean corpuscular haemoglobin concentration (MCHC) values ranged from 40.08-137.05. Lakurbe *et al.* (2020) obtained a higher value of 29.70-31.75g/dl. A high MCHC above the normal range may be an indication of a type of anaemia-Autoimmune haemolytic anaemia which may be due to medications. Dehydration may result in high MCHC (Lynne 2022) since birds were starved of feed and water before slaughter. MCH values ranged from 63.73-67.78pg. This values were higher than 18.06-22.76pg reported by Medugu *et al.* (2010) and 46.25- 48.30pg as reported by Lakurbe *et al.* (2020).

The Economic of Production of Broiler Chickens fed Diet Containing Different Levels of Local White Sorghum as replacement for White Maize is shown in table 5 below

Table 5 presents the economics of production of broiler chickens fed white sorghum (*Farfara*) as replacement for white maize. The study revealed that the total feed intake ranged from 3.84 g - 4.22g. The highest cost per kg feed (₦319.68) was in diet 3 and the lowest in diet 5 (₦305.61). Total feed cost (₦) was highest in diet 5 (₦1289.66). This contradicts the report of Ibitoye *et al.* (2012); Etuka *et al.* (2012); Adamu *et al.* (2013); Aladeen *et al*. (2013) reported a significant reduction of cost of production when sorghum completely replaced maize in broiler chicken diets. The total weight gain (1.36kg) was highest in diet 2 and lowest (1.28kg) in diet 4. Feed cost per weight (kg) gain was lowest (₦923.38) in diet 1 and highest (₦969.67) in diet 5. This result agreed with findings of Ibe *et al.* (2013) who reported that broiler chickens fed 100% replacement of maize with white sorghum had the highest cost of feed per kg weight gain. This can be attributed to the nutrient contents of grain especially energy. Yasin (2022) stated that the major energy source used in poultry feed formulation is maize (Yasin, 2022). According to the report, sorghum contains nutritive value similar to those of maize. According to Olomu (1995) the metabolisable energy and crude protein of sorghum are 3270kcal/kg and 95% respectively is comparable with 3319kcal/kg and 10.1% of crude protein respectively of maize. Yasin (2022) reported that energy level of the feed was the major factor influencing feed intake as birds will eat to satisfy their energy needs. This explains the highest feed intake, total feed cost and feed cost per kilogram weight gain recorded in diet 5.

Table 5: Economic of production of broiler chickens fed white sorghum (*Farfara*) as replacement for white maize (2-7weeks).

Parameters	Diets				
	1	2	3	4	5
Total feed intake (kg)	3.98	4.08	3.84	3.89	4.22
Feed cost (₦/kg)	310.89	309.78	319.68	306.97	305.61
Total feed (₦)	1237.34	1263.90	1227.57	1194.11	1289.66
Total weight gain (kg)	1.34	1.36	1.27	1.28	1.33
Feed cost per kg gain (₦)	923.38	929.34	951.60	932.90	969.67

CONCLUSION

Based on the results, it can be concluded that white sorghum can replace white maize up to 75% without adverse effect on performance of broiler chickens. White sorghum may not have adverse effect on blood of broiler chickens. Diet 4 (75% level of replacement) had the lowest total feed cost and therefore can be considered profitable in terms of cost benefit.

RECOMMENDATIONS

It could therefore be recommended that white sorghum (*farfara*) may be included up to 75% level to replace white maize in the diets of broiler chickens. Poultry farmers should be encouraged to explore many techniques used in reducing or removing the tannin content in sorghum. Diet 2 could be recommended for raising broiler chickens.

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OXYTETRACYCLINE RESIDUE LEVELS IN CATTLE AND PIGS SLAUGHTERED IN KADUNA METROPOLIS, NORTH WEST, NIGERIA

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ABSTRACT
The study aimed to screen and determine the presence of oxytetracycline (OTC) residue in edible tissues of cattle and pigs slaughtered in Kaduna metropolis, Northwest, Nigeria. Microbial inhibition test and high-performance liquid chromatography analysis were used to screen and quantify, the residues of oxytetracycline in liver, kidney and muscle tissues. The results showed that of the samples collected for cattle (150) and pigs (150), 60 (40%) and 40 (26.66%) tested positive for antimicrobial residue in cattle and pigs, respectively, with various levels of zone of inhibition. Out of the positive samples in cattle, 45 (75%) had oxytetracycline residue in excess of acceptable regulating levels with the highest concentration found in the kidney tissue. The study also revealed that 15 (37.55%) of the positive samples had OTC residues in pigs with more occurring in the liver, kidney, and muscle. The mean concentrations of OTC hydrochloride residue across cattle sample tissues were above maximum residue limits of 0.2 µg/g, 0.6 µg/g, and 1.2 µg/g for meat, liver and kidney, respectively, whereas for pigs, the mean concentrations of OTC residue were lower than set residue limits. The obtained OTC levels for pork were relatively safe when compared to that of edible beef tissues. There is an urgent need for stricter regulations and monitoring of antimicrobial drugs usage in the livestock industry to ensure safety of meat products for human consumption.
Keywords: *Oxytetracycline residue, meat, cattle, pigs, Kaduna metropolis*

INTRODUCTION
The use of antibiotics for the treatment of clinically sick animals, disease prevention and promotion of growth is on the increase due to the intensification of farming practices in the developing countries including Nigeria (Adesokan *et al.*, 2013). Oxytetracycline (OTC), a broad spectrum and bacteriostatic antibiotic is widely used to treat gram positive (*Streptococcus* spp.; *staphylococcus* spp.) and gram negative (*Escherichia coli*) bacteria, ricketsiae (*Anaplasma*, *Cowdria*, and *Ehrlichia*s pp.), chlamydiae (*Psittacosis*, *Trachoma*, *lymphogranuloma venereum*) and some protozoa (*Theileria* and *Babesia* spp.) diseases in animals (Aliu *et al.*, 2007; Nonga *et al.*, 2009). The long acting oxytetracycline (LOTC), because of its convenience of administration, wide antibacterial activity and the challenges of accurate bacterial diagnosis under field practice, are widely used to treat a wide range of disease, often indiscriminately. A single injection of LOTC can keep high concentrations in plasma above minimum inhibitory concentration for several days thereby decreasing the number of administrations per treatment (Aliu, 2007). As a result of ready availability of the product at informal markets and lack of restrictions on usage being imposed, OTC has been used indiscriminately by laymen and non-professionals alike in the treatment of various kinds of diseases. Thus, OTC has become a source of concern for residue monitoring authorities around the world.

Consuming meat with high levels of OTC residues could lead to gastrointestinal disturbances, hypersensitivity, bone and teeth problems in children and the development of bacterial resistance (Olatoye and Ehinmowo, 2010). This is because improper dosage of OTC especially at sub therapeutic levels can result in acute or chronic public health problems that could be toxicological, microbiological or immunological (Josiah *et al*., 2018). There is a dearth of data on the levels of OTC residues in cattle and pig carcasses slaughtered within Kaduna metropolis, hence this study. The information from the study can inform regulatory authorities and guide decision making on some edible livestock products.

MATERIALS AND METHODS

This study was conducted to screen for antimicrobial residues and evaluate the levels of OTC residues present in slaughtered cattle carcasses from Kakuri, Kawo and Tudunwada abattoirs and pig carcasses from Barakallahu, Kurminmashi, Narayi and Ungwan Television slaughter slabs, in Kaduna rural and urban metropolis. Kaduna is situated in the Northern guinea savannah zone between latitudes 11^0 and 12^0N and longitudes 7^0 and 8^0E at an elevation of 650 m above sea level. The average annual maximum and minimum temperature are between 31.0±3.2 and 18.0±3.7^{0}C . The average annual rainfall is 1100 mm lasting from May to October with a mean relative humidity of 72%. The dry season lasts from November to April with mean daily temperature ranging from 15^0C - 36^0C and mean relative humidity 20% - 37% (Rekwot *et al*., 1998).

Study design and sample collection

Animals were selected randomly across the abattoirs and slaughter slabs within Kaduna metropolis. Three samples (muscles, liver and kidney) of 100-200 g each were obtained from 10 -15 cows and pigs yielding a total of 30-45 tissue samples each per collection. To increase randomization, samples were collected weekly over a period of five weeks yielding 150 samples each for cattle and pig carcasses. Each collected sample (100 – 200 g) was packaged in a zip-lock polythene bags and stored under ice in a cooler box prior to transportation to the laboratory. The samples were stored in Deep freezer at - 4^0C for approximately a week before analysis.

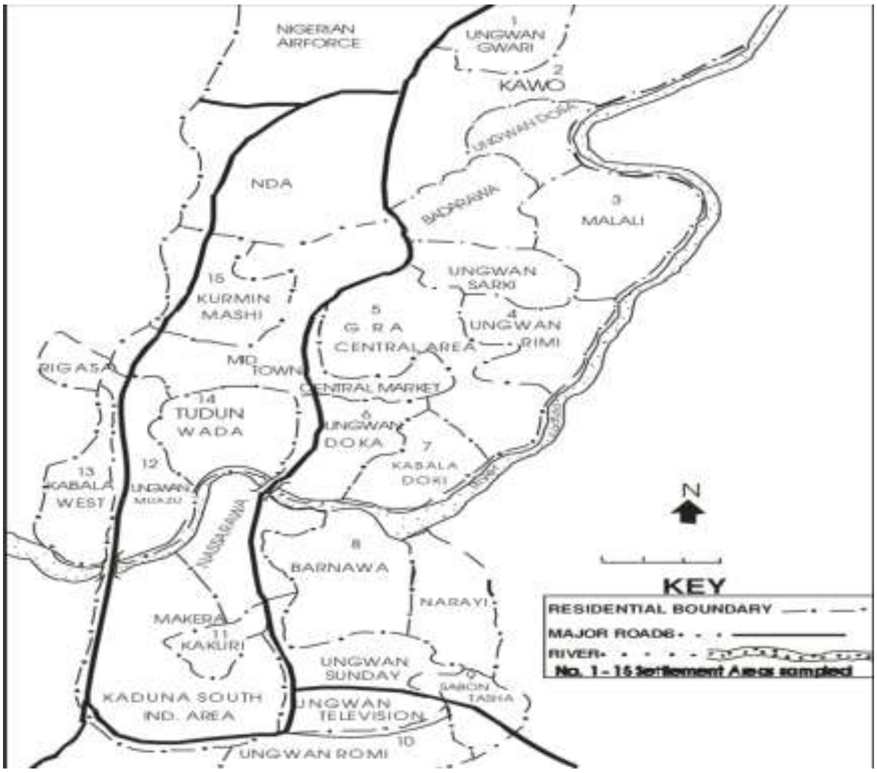

Figure 1. Map showing the location of the study sites (abattoirs/slaughter slabs) within Kaduna metropolis

Sample analysis

Samples were prepared and analyzed at the Department of Public Health Laboratory, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria. A validated analytical method was used in sample processing and analysis. Samples were removed from the freezer to attain room temperature 19-25^0. An adapted microbial inhibition test was used to screen samples for evidence of antimicrobial drug residue as described by (Ezenduka and Ugwunba, 2012). The presence of antimicrobial agents in each of the samples was confirmed by a complete zone of inhibition of microbial growth in an annular zone not less than 2 mm around the samples. Less than 2 mm inhibitory zone indicate negative result.

Oxytetracycline residue analysis of sample

High performance liquid chromatography (HPLC) standard methods were used for antibiotic residue analysis. The OTC concentrations were determined according to a previously described technique (Kimera *et al*., 2015).

Data Analysis

The data were analysed using graph pad prisim® version 8 for windows, Graphpad software, San Diego, California, USA, www.graphpad.com. Descriptive statistics were used to compute means, standard error of mean and a range. A P-value of less than 0.5 was considered statistically significant. Analysis of variance was used to compare differences in means of continuous variables

RESULTS

A total of 300 samples of edible tissues (kidney, liver and meat) comprising cattle (150) and pig (150) were screened for antimicrobial residues. Out of this number 60 (40%) and 40 (26.67%) tested positive to antimicrobial residues for cattle and pigs, respectively, with various zones of inhibition, while 90 (60%) and 110 (73.33%) tested negative for cattle and pigs, respectively. The mean concentration of oxytetracycline residues in cattle across all tissues was 2,902.5µg/kg ±380.5µg/kg. For the respective tissues types the concentrations were 2,105.6±201.8 µg/kg for muscle, 2,924.5±105.6 µg/kg for livers and 3,012.8±305.1 µg/kg for kidney tissues. Oxytetracycline concentrations were highest in the kidney tissues while lower concentrations of oxytetracycline were found in samples from Kawo abattoir. For pigs, the highest concentration of OTC residue was 470.5µg/kg found in the liver, while the mean concentrations across tissues were 109±7.05 µg/kg, 304± 0.85 µg/kg and 270 ±1.09 µg/kg for muscle, liver and kidney, respectively. The obtained levels in pig samples may not induce adverse effects for consumers. Cattle meat was more likely to be positive for antibiotic residue than pig meat.

Table 1: Proportion of Muscle, Liver and Kidney Samples of Cattle and Pigs for Kaduna Metropolis that contained Antimicrobial Residues

Animal spp	Location (Abattoirs)	Positive Samples (% Positive)	Muscle (% Positive)	Liver (% Positive)	Kidney (% Positive)
Cattle	Kakuri (n = 45)	23 (51.1%)	7/15 (46.67)	8/15 (53.3%)	8/15 (53.3%)
	Kawo (n = 45)	14 (31.11)	3/15 (20.0)	6/15 (40.0)	5/15 (33.3)
	T/Wada (n = 60)	23 (38.33)	7/20 (35.0)	6/20 (50.0)	10/20 (30.0)
Total	150	60	17	20	23
Pigs	Barkallahu (n = 30)	6(20%)	2/10 (20.0)	2/10 (20)	2/10 (20.0)
	KurmiMashi (n=45)	12 (26.7)	3/15 (20.0)	5/15 (33.3)	4/15 (26.7)
	Narayi (n=30)	8 (26.7)	2/10 (20.0)	3/10 (30.0)	3/10 (30.0)
	U/Television (n=45)	14 (31.1)	4/15 (26.7)	5/15 (33.3)	5/15 (33.3)
Total		40	11	15	14

DISCUSSION

Oxytetracycline (OTC) is one of the most commonly used over the counter antibiotics by livestock keepers in African countries, including Nigeria, for the treatment of diseases and other extra label uses (Olatoye and Ehinmowo, 2010). The presence of their residues or metabolites in animal products could have adverse effect on consumer's health. The results of this study indicate the presence of OTC residues in 40% and 26.7% of cattle and pigs samples respectively, with a notable number of samples in cattle and only two samples of pigs being above the acceptable maximum residue of 0.2 µg/g, 0.6 µg/g, and 1.2 µg/g recommended for meat, liver and kidney, respectively (WHO/FAO, 2002). The occurrences of antimicrobial residues in meat, liver and kidney have been reported by several authors (Kabirungi *et al.*, 2022; Mohammed *et al.*, 2022; Adam *et al.*, 2020). However, the OTC levels in this study were lower than that reported in previous studies (Adam *et al.*, 2020; Olufemi and Agboola, 2009; Ezeduka and Ugwumba, 2012) although comparable with 46% in beef reported by Akinwumi *et al.*, 2012 or 41.2% reported by Mmbado, 2004 from Tanzania. The differences in the OTC levels recorded in our study and previous studies could be due to differences in sample size and analytical techniques used for the detection and qualification of OTC residues (Kambirungi *et al.*, 2022). Other factors could be due to differences in climatic factors, age and breed of the cattle slaughtered and the local regulation of antibiotic applications among farmers in different countries (Mohammed *et al.*, 2022).

The relatively low prevalence of antimicrobial residue in this study could probably be due to low doses of antimicrobial usage by livestock traders in order to maximize the number of dosage available (Adesokan *et al.*, 2013). Nomadic herdsmen have been reported to administer chemotherapeutic agents without veterinary prescription, and most likely at incorrect dosage (Olatoye and Ehinmowo, 2010). The prolonged antimicrobial usage at low doses in food animals, could pose a significant risk factor for the development of antimicrobial resistance among bacterial pathogens (Blake *et al.*, 2003; Varga *et al.*, 2009). On comparing the OTC levels in cattle and pigs slaughtered within Kaduna metropolis, this study found out that cattle meat was more likely to be positive for antibiotic residue than pig meat. This has exposed a potentially serious threat for consumers of bovine meat product in Kaduna metropolis.

CONCLUSION

This study indicated that the overall OTC residues positive for cattle samples was 40% distributed as 20%, 44.44% and 35.56% for Kawo, Tudun wada and Kakuri abattoirs respectively. Out of the positive samples, 45/60 (75%)

had OTC in concentration above the recommended maximum residue limits (MRLS). The levels of OTC residues in the cattle tissues followed the order Kidney, liver and muscle. These high concentrations present public and veterinary health threats. Only two samples had concentration above MRLS in pig and mean concentrations were below the acceptable FAO/WHO MRL recommendation. Thus, cattle meats are more likely to contain antimicrobial residues than edible pig products. The enforcement of regulations on indiscriminate use of antibiotics and adherence to withdrawal period of drugs would mitigate antimicrobial resistance threat to public and veterinary health.

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A PRELIMINARY ASSESSMENT OF PASTURE GRASSES PREFERENCE TOWARDS *DE NOVO* DOMESTICATION OF WEED-PASTURE SPECIES IN SOUTHERN AGRICULTURAL ZONE OF NASARAWA STATE, NIGERIA

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ABSTRACT
Because of the world's rising population, global food security is under threat. As a result, feeding the world's population and ending hunger by 2030 will necessitate deliberate activities such as weed-pasture domestication. This study was conducted to preliminarily assess the preferences for weed pasture grasses for de novo domestication in the southern agricultural zone of Nasarawa State, Nigeria. A multi-stage sampling technique was used to select 45 herders across three Local Government Areas (LGAs) in the zone. The results indicate that urbanization (95.6%) is the major reason for feed scarcity. Majority of the respondents (80%) perceived that displacement of pastures with noxious weeds is one of the reasons for feed scarcity. Moving animals to pre-urban areas (97.8%), exploitation of lowland areas (77.8%), moving cattle to the southern region (73.3%), ranching (68.9%), and exploitation of fresh pastures (64.4%) were the key tactics recognized by herders to cope with feed scarcity. The most preferred grasses were Guinea grass (Panicum maximum), Kyasuwa (P. pedicellatum), and Gamba grass (Andropogon gayanus) because of nutritional content, palatability, and palatability of the grasses.
Keywords: *Denovo, pasture grasses, preference, domestication, herders*

INTRODUCTION
Global food security is under strain due to the world's growing population (Ahmad *et al.,* 2021). Furthermore, increased competition for land, farmer-herder conflicts, as well as climate change and concomitant environmental degradation, are all threatening livestock productivity. According to United Nation's estimate, the global population and food consumption would both increase to 8.5 billion people and 11.6 billion tons by 2030. If current trends continue, the number of hungry people might reach 840 million by 2030 (Ahmad *et al.,* 2021). To avoid this, the United Nations adopted "Zero Hunger" as the second Sustainable Development Goal (SDG2). However, Agriculture's present production is inadequate; feeding the world's population and attaining zero hunger by 2030 will need purposeful actions such as weed-pasture domestication (de novo domestication inclusive) for improved animal production. According to Fernie and Yan (2019) putting wild weed-pasture species under human control might help ease many of these burdens.

Most crop and plant species we have today became popular due to domestication from their wild ancestors during the last 12,000 years (Fernie and Yan, 2019). Ewing (2017) argued that fundamental goal of weed-pasture domestication is to identify species that can fulfil a position in the farming system that is now unfilled by another species. The underlying issue when considering a new venture is: can a modification to the present agricultural system with the addition of a new pasture specie make the system more lucrative; and what important features would the plant require to thrive in that role? Only in the last 50–60 years has science begun to get an understanding of the vast number of plant species that support humanity (Hammer and Khoshbakht, 2014). Globally, the production of livestock is heavily reliant on pasture. Grasses and forage species provide significant value to dairy, beef, wool, lamb, and other products through pasture production (Mitchell *et al.,* 2013). Forage and fodder crops provide forage and fodder to around 97 percent of Nigeria's ruminant livestock (Garba *et al.,* 2020). Feed supplies (including weeds and pasture) vary greatly and are distributed across the country's major agro-ecological zones. There is about 32.42 million hectares of grazing lands in Nigeria (Shiawoya *et al.*, 2011). Unfortunately, extensive areas of the grazing lands are composed of indigenous species, which are of low in yield and quality. Furthermore, forage for cattle grazing is scarce in some parts of the nation during certain times of the year, leading in nomadism and, as a result, farmer-herder clashes.

Because northern Nigeria has a single rainy season, cattle producing operations need a high level of movement in pursuit of fresh pastures in the country's moister areas, particularly during the dry season. These cattle migratory patterns from the arid Sahel and Sudan zones to the wetter Guinea and Rainforest zones include incursions onto farmer crops, which frequently lead to violence. Due to difficulties of land availability and access, there is increasing conflict between nomadic pastoralists and established farmers in most West African nations, especially Nigeria (Usman and Nichol, 2022). This has resulted in an increase in clashes between pastoralists and farmers in most parts of the Nigeria, frequently ending in numerous deaths (Orji, 2021; Nwangwu *et al.*, 2020, Onah *et al.*, 2020, Odoh and Chilaka, 2012). Between 2000 and 2016, about 8000 people died in Nigeria because of pastoral-farmer violence (Institute for Economics and Peace, 2021). Hence, the need to develop or adopt strategies, or technologies that will assist species to cope with and even overcome most of the factors which militate against high availability and productivity of pasture (Shaiwoye *et al.*, 2011), across all ecological zones, always.The objectives of the study are to: identify the causes of feed scarcity and strategies for curtailing feed scarcity; and to assess preference for pasture grasses and the reasons for the preference.

MATERIALS AND METHODS

The preliminary survey was carried out 2022 across the Southern Agricultural zone of Nasarawa state. The field experiments for *De novo* domestication of the most preferred grasses is currently ongoing at the Teaching and Research Farm of the Faculty of Agriculture, Nasarawa State University Keffi, Nasarawa State Nigeria (latitude 08°33N and longitude 08°32E, msl). A multi-stage sampling approach was used to perform a survey on weed-pasture species in the Southern Agricultural Zone of Nasarawa State. Three (3) Local Government Areas (LGAs) were chosen at random in the first stage. The second stage was a purposive selection of three communities. The selection of communities was based on the areas noted for high grazing activities. This was followed by a random sampling of five (5) herders in each community selected making a total of forty-five (45) herders. For quick identification of weed pasture species, Akobundu and Agyakwa's Handbook of West African Weeds, published in 1998, was used. The data collected was subjected to descriptive statistics such as means, frequencies and percentages using Statistical Package for Social Sciences (SPSS) Version 21.

RESULTS AND DISCUSSION

Causes of Feed Scarcity

The general perception of herders on the possible reasons for feed scarcity is presented in Figure 1: The results indicate that urbanization (95.6) is the major reason for feed scarcity. Majority of the respondents (80%) perceived that displacement of pastures with noxious weeds is one of the reasons for feed scarcity. Other possible causes include walking duration, extinction of pasture species, climate change, and herbicides application with 73.3%, 55.6%, 26.7%, and 2.2% respectively. This agrees with Aremu (2022) who posits that climate change and competition between humans and livestock causes feed scarcity. Similarly, Abdulrahman *et al.* (2022) established that erratic rainfall due to climate change, and hoarding of feed increases the cost of feed which by implication leads to feed scarcity.

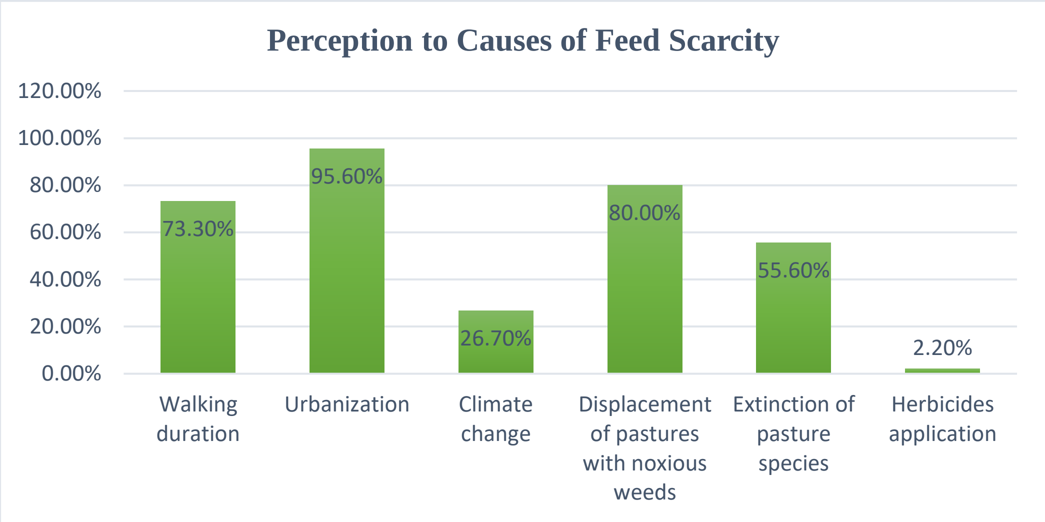

Figure 1: Herders' perception to causes of feed scarcity
Source: Field Survey 2022

Strategies to Curtail Feed Scarcity

Figure 2 depicts herders' perceived techniques for reducing feed scarcity. Moving animals to pre-urban areas (97.8%), exploitation of lowland areas (77.8%), moving cattle to the southern region (73.3%), ranching (68.9%), and exploitation of fresh pastures (64.4%) were the key tactics recognized by herders to cope with feed scarcity. Other techniques include herd division, land ownership, and the use of a semi-intensive cattle production approach. According to Abdulrahman *et al.* (2022) the best coping strategy to feed scarcity especially as a result of high cost feed is the use of alternative feed sources based on availability.

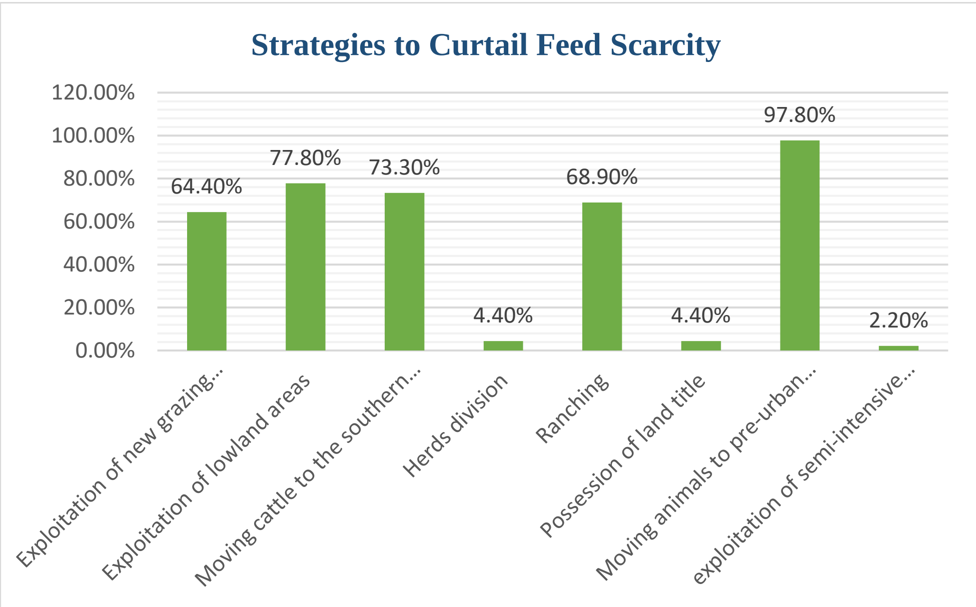

Figure 2: Herders' perception on strategies to curtail feed scarcity
Source: Field survey 2022

Pasture Grass Preference

Table 1 presents the common grasses preferred by cattle as reported by the herders. It was found that the most preferred grasses were Guinea grass (*Panicum maximum*), Kyasuwa (*P. pedicellatum*), and Gamba grass (*Andropogon gayanus*) with 86.7%, 75.6%, and 73.3% respectively. According to Ekwe *et al* (2020), grasses, legumes, and trees are the most preferred forage species while the least preferred forage is *Leucana leucocephala*. Goats show higher preference for grasses especially *Andropogon gayanus, Andropogon tectorum, and Panicum maximum* (Ekwe *et al.*, 2020).

Table 1: Preferences for Pasture Grasses

Grass	Frequency	Percentage
Gamba (*Andropogon gayanus*)	33	73.3
Southern Gamba *(Tectorum)*	5	11.1
Carpet (*Axonopus compressus*)	2	4.4
Imperial (*A. scoparius*)	6	13.3
Signal (*Bracharia documbens*)	5	11.1
Para (*B. mutica*)	6	13.3
Palisade (*B. brizantha*)	4	8.9
Rugu, Congo (*B. ruziziensis*)	18	40.0
Buffel (*Cenchrus ciliaris*)	1	2.2
Rhodes (*Chloris gayana*)	19	42.2
Pangola (*Digitaria documbens*)	2	4.4
Guinea (*Panicum maximum*)	39	86.7
Kyasuwa (*P. pedicellatum*)	34	75.6
Spear (*Imperata cylindrica*)	4	8.9
	178*	

Source: Field survey 2022 ***Multiple responses were allowed**

Reasons for Grass Preference

The common reasons for grass preference reported by the respondents are presented in figure 3. According to the findings, all the respondents (100%) agreed that grasses are preferred because of nutritional content and palatability. Majority of the respondents (88.9%) also agreed that preference for grasses is due to their availability. Only few (8.9%) attributed the reason for preference to cost of grasses. This quite agrees with the findings of Ekwe *et al* (2020) who revealed that accessibility and palatability are important determinants of preference and/or choice of forage species.

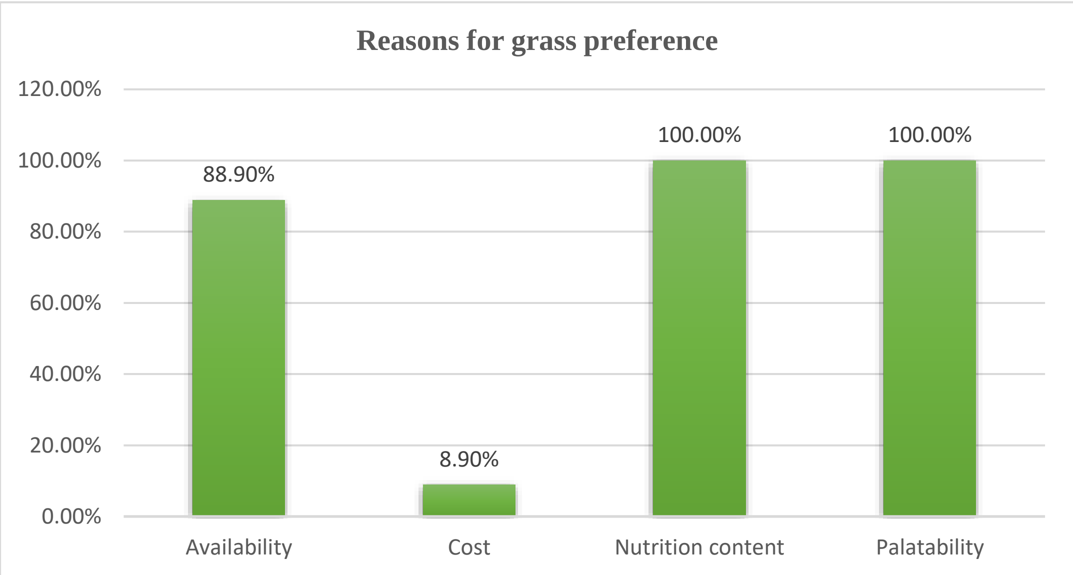

Figure 3: Perceived reasons for grass preference.
Source: Field survey 2022

CONCLUSION

Feed scarcity is caused by urbanization, the substitution of meadows with noxious weeds, and the length of time spent walking. transferring animals to pre-urban areas, utilizing lowland areas, transferring cattle to the southern region, ranching, and utilizing fresh pastures are keyways for dealing with feed scarcity. Guinea grass (*Panicum maximum*), Kyasuwa (*P. pedicellatum*), and Gamba grass (*Andropogon gayanus*) are the most favoured grasses among herders in Nasarawa state due to nutritional content, palatability, and availability.

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EFFECTS OF PROBIOTICS ARTICHOKE (*CYNARA SCOLYMUS)* ON GROSS PERFORMANCE OF COCKERELS FED SWAPSI-BASED DIETS

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ABSTRACT
The effects of probiotics Artichoke (Cynara scolymus) on performance of cockerels fed SWAPSI-based meal diets were studied using 144 day old cockerels in a 3×2 factorial arrangement .The diet is T1 0% probiotics 0% garlic, T2; 0% probiotics 0.05% garlic, T3; 0.05% probiotic A 0%garlic ,T4; 0.05% probiotic A 0.05% garlic, T5; 0.05% probiotic A 0 garlic%,T6; 0.05%probiotic B 0% garlic. Feed and water were provided ad libitum. Parameters measured were final body weight, total weight gain, average daily weight gain, average feed intake, weight gain, feed conversion ratio performance index, protein intake, protein efficiency ratio, energy intake, energy efficiency ratio and survival group fed probiotic A, the results showed significant depression (P<0.05) in the final body weight, average total weight gain, average final weight and performance index compared to the control.

INTRODUCTION
In the face of increased demand for poultry products use of alternative feed stuff as supplementary feed to replace grains and seeds as sources of proteins and energy such as sugar cane waste products (Alu *et al*., 2018). Earlier use of antibiotics in diets of monogastrics (Frost, 1991) as growth promoters became essential worldwide, however, the possibility of developing resistant population of bacteria strain of bacteria including *Salmonella spp,* has residual effects such as allergy in farm animals and humans. These led to the European Union stoppage on their usage as feed additives (Ari *et al*., 2012). Therefore, an intense search for replacements such as probiotics, phytogenics and other feed additives has taken place in the last decade (Ari *et al*., 2012). Agro-byproducts such as sugarcane peels gotten after the processing of sugar from sugarcane are believed to contain high amount of nutrients yet, are often left unutilized and are discarded as unwanted. One of such unwanted products is the solid waste productof sugar industry (SWAPSI) encompassing of the scrapping, peels and baggase of sugar cane. It is alleged to be of nutritional value in terms of energy and other nutrients. The objective of this research was to determine the effects of probiotics on the performance of cockerels fed SWAPSI meal- based diets.

MATERIALS AND METHODS
Experimental Site
The experiment was conducted at the College of Agriculture, Science and Technology Livestock complex Doma Road Tudun-Amba, Lafia, Nasarawa State

Sources and preparation of ingredients
The solid waste product of sugar industry (SWAPSI) were sourced from Dangote sugar processing industry in Numan LGA of Adamawa State, sun-dried for 2 - 3 days. Thereafter, it was ground to produce SWAPSI meal. Other ingredients such as, probiotics were purchased from Global Feed Resources Limited, Abuja. A total of 144 day-old cockerel chicks were obtained from Agric International Technology and Trade (Agrited) hatcheries. The birds were reared in deep litter house partitioned using wire mash. Heat and light were provided throughout the brooding phase using electric bulb. Routine vaccinations (Gomboro and Lasota) were administered and all other routine medications and management practices were adhered to as recommended by Ari *et al.* (2012). Feed were given after weighing and fresh water was provided *ad libitum*. The experiment lasted for a period of 112 days.

Table 1 Gross composition of the experimental diets for grower cockerels

Ingredients	T1	T2	T3	T4	T5	T6
Groundnut cake	25.00	25.00	25.00	25.00	25.00	25.00
Maize	38.00	38.00	38.00	38.00	38.00	38.00
Rice offal	5.00	5.00	5.00	5.00	5.00	5.00
SWAPSI	25.00	25.00	25.00	25.00	25.00	25.00
Blood meal	2.00	2.00	2.00	2.00	2.00	2.00
Bone ash	1.00	1.00	1.00	1.00	1.00	1.00
Palm oil	3.00	3.00	3.00	3.00	3.00	3.00
Salt	0.25	0.25	0.25	0.25	0.25	0.25
*Premix	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25	0.25
Probiotic type (**A** or **B**)	0.00	0.00	0.05**A**	0.05**A**	0.05**B**	0.05**B**
Garlic(g)	0.00	0.05	0.00	0.00	0.00	0.05
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated nutrient and energy composition						
Energy (kcal/kg,	3000.1	3000.1	3000.1	3000.1	3000.1	3000.1
Crude protein (%)	18.27	18.27	18.27	18.27	18.27	18.27
Crude fibre (%)	7.44	7.44	7.44	7.44	7.44	7.44
Ether extract (%)	4.47	4.47	4.47	4.47	4.47	4.47
Ash (%)	3.95	3.95	3.95	3.95	3.95	3.95
Phosphorus (%)	2.57	2.57	2.57	2.57	2.57	2.57
Calcium (%)	1.43	1.43	1.43	1.43	1.43	1.43

*Premix= A15,000 I.U, vitamin D3 300,000 I.U., vitamin E 3,000 I.U., vitamin K 2.50mg, vitamin B1 (thiamin) 200mg, Riboflavin (B2) 600mg, pyridoxine (B6), Niacin 40.0mg, vitamin B12 2mg, Pantothenic acid 10.0mg, folic acid 100mg, Biotin 8mg, choline chloride 50mg, anti-oxidant 12.5mg, manganese 96mg, zinc 6mg, Iron 24mg, Copper 0.6mg, Iodine 0.14mg, Selenium 24mg, cobalt 214mg

A-*Cynara scolymus extract*, ***B****-baccillus subtillis, garlic*

Survival Percentage

Survival percentage % =100% - mortality percentage

*Mortality %=total number of death animals over total number of animals raised.

Performance Index

$$\text{Performance index} = \text{survival } \% \times \text{weight gain/bird/week (g)} \times \frac{100}{\text{FCR}}$$

Protein Efficiency Ratio (PER)

$$\text{Protein efficiency ratio} = \frac{\text{Body weight gain (g)}}{\text{Protein intake (g)}}$$

*protein intake=feed intake (dry matter) × percentage protein in diet

Energy Efficiency Ratio

$$\text{Energy Efficiency Ratio} = \frac{\text{Bodyweight gain (g) x 100}}{\text{Total metabolizable energy intake}}$$

*Metabolizable Energy: using pauzenga formula (1985)

ME=37 x % CP+81 x % EE+35.5 x % NFE

RESULTS AND DISCUSSION

Table 2: Effect of probiotics Artichoke (*Cynara scolymus*) on growth performance of growing cockerels fed SWAPSI meal-based diets

	Probiotics a			
Parameters	**0 %**	**0.05%**	**SEM**	**LOS**
Initial body weight (g/bird)	608.50	607.12	40.57	NS
Av.Final body weight (g/bird)	1238.06 ^{a}	978.95^{b}	55.19	*
Av. Total weight gain (g/bird)	629.56 ^{a}	371.83^{b}	37.55	*
Av. Weight gain (g/bird)	11.24 ^{a}	6.64^{b}	0.62	*
Av. Final weight (g/bird)	100.39	83.10	3.24	*

Feed conversion ratio	11.31	12.68	1.39	NS
Protein intake (g/bird)	9.84	9.50	0.36	NS
Protein efficiency ratio	5.19	4.87	0.18	NS
Energy intake (g/bird)	137.76	133.01	5.09	NS
Energy efficiency ratio	37.12	34.81	1.31	NS
Performance index (%)	71.17[a]	51.25[b]	3.94	*
Survival (%)	100.00	100.00	0.00	NS

ab means on the same row bearing different superscripts are significant (P<0.05), **NS**= Not significant (P>0.05), **SEM**= Standard error of means, **LOS**= Level of significance.

Performance response

Performance of grower cockerels feed SWAPSI based-meal diets (table 2) shows that the average final body weight, average total weight, average daily weight gain and performance index were significantly reduced (p< 0.05), in contrast with Karimi *et al.* (2020) who reported no significant differences (p> 0.05) in body weight when birds were fed aqueous extract of *Cynara scolymus*. Tajodini *et al.* (2015) also observed lower body weight as compared to the control. On the effect of probiotic Artichoke (*Cynara scolymus)* on FCR, there was an improvement on the birds during 21-35 days of experiment as reported by Karimi *et al.* (2020).

CONCLUSION AND RECOMMENDATION

The objective of this research was to determine the effect of probiotics Artichoke (*Cynara scolymus)* on performance of cockerels. From the results cockerels fed probiotics Artichoke (*Cynara scolymus*) supplemented diets showed reduced body weight but increased FCR. Therefore it is recommended to cockerels to efficiently convert feed to weight gain.

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USE OF TAURINE AS A STRATEGY FOR MULTI – DIMENSIONAL APPROACH TO LIVESTOCK DEVELOPMENT: EFFECT ON SERUM BIOCHEMISTRY OF WEST AFRICAN DWARF SHEEP.

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ABSTRACT
The experiment was conducted to study the antioxidant effect of taurine on serum biochemistry of mixed sex West Africa Dwarf (WAD) sheep fed taurine supplemented diet. Thirty-two WAD sheep with an average weight of 12kg were used in a completely randomized design involving four dietary treatments (T1, T2, T3 and T4) containing 0, 0.5, 1 and 1.5% levels of inclusion of taurine respectively. Blood sample was collected from each animal and were investigated to determine total protein (TP), albumin, globulin, glucose, aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP) cholesterol and triglycerides. The TP value was highest in sheep fed T4 (9.00g/dl) which was statistically similar ($p<0.05$) to sheep fed T3 (8.89g/dl) and diet T2 (8.75g/dl) while sheep fed T1 had the least value7.89g/dl Albumin values ranged from 4.31g/dl (T1) to 4.88g/dl (T3). Globulin values varied from 5.18g/dl (T1) to 6.81g/dl (T3). The total glucose recorded varied from 46.25mg/dl (T4) to 62.11(T1). The transaminase enzymes activities (ALT, AST and ALP) were significantly affected by the dietary treatments, there were significant differences ($P<0.05$) in the concentration of cholesterol and triglycerides. There was an extensive variation in the serum biochemical values for sheep fed the control compared to other sheep fed the supplemented diets. It was therefore concluded that taurine may be an anti-oxidant with immense quality which could be incorporated into the diets of sheep for optimal performance.
Keywords: *Antioxidant, Taurine, Serum biochemistry, West African Dwarf, Sheep*

INTRODUCTION
Livestock reared in the tropical region are highly vulnerable to the impact of climate variability and extremity (Mondal and Reddy, 2017). Habeeb *et al*. (2018) reported that small ruminants have a faster breeding or shorter generation interval (about 5 months) and reaching maturity faster than cattle. However, they are susceptible to extreme environmental conditions which lead to stress, characterized with discomfort and subsequently at the extreme to death (Mondal and Reddy, 2017). Antioxidant supplementation provides valuable effects against oxidative stress. Taurine (2-amino-ethanesulfonic acid, $C_2H_7NO_3S$) is a conditional beta-amino acid (De Bertozo *et al*., 2016) involved in a numerous physiological processes like bile acid conjugation, osmo-regulation, neuronal excitability, inflammatory reactions, glucose metabolism, membrane stabilization, lipid metabolism and modification of cholesterol, modulation of cellular calcium flux and regulation of immunity and detoxification (Afsal *et al*., 2018). Haematological and serum biochemical values have been considered useful for the assessment of body condition, nutritional and immune status in animal where other tissue related measurements are not available (Njidda *et al*., 2014).

MATERIALS AND METHODS
Experimental Site
The experiment was carried out at the Small Ruminant Unit of Kogi State Ministry of Agriculture, Kabba located within the Southern Guinea Savannah Zone on latitude $7^{0}5'$N, longitude $6^{0}4'$E and altitude of 640m above sea level. It has an annual rainfall of 1,500mm and rain starts between late April and early May to October. The dry season begins around the middle of November, with cool weather that ends in February. This is followed by relatively hot-dry weather between March and April just before the rain begins. The minimum daily temperature

is from 14^{o}C - 20^{o}C during the cool season while the maximum daily temperature is from 19^{0}C- 40^{0}C during the hot season. The mean relative humidity during dry and wet seasons is 21% and 72%, respectively (Cite).

Experimental Diets

Diets were formulated with graded levels of supplemental taurine at 0, 0.5, 1.0 and 1.5 respectively (Table1) to meet the nutrients requirement of sheep. They were fed at 3% of their body weight. Drinking water was provided daily *ad libitum*.

Table 1: Experimental Diets

Ingredients	Levels of inclusion (%)
Maize offal	78.0
Soya bean cake	6.5
Groundnut cake	8.6
Oil	5.0
Limestone	1.5
Salt	0.4
Metabolizable Energy (Kcal/kg)	2800

Experimental Design and Management of Animals

A total of thirty-two West Africa Dwarf sheep of both sexes were purchased from the open market within Kabba and used for this experiment with an average body weight of 12kg. On arrival, they were given prophylactic treatment and quarantined for two weeks during which they were treated against ecto-parasite using Diasentol and dewormed with Albendazole (2.5% oral suspension) per kg body weight. Experimental diets were fed immediately after acclimatization and were divided into four treatment groups with four replicates in a completely randomized design.

Serum Biochemical Evaluations

Blood samples (2 ml) was collected from the jugular vein from four sheep per treatment at the end of the trial using 2.0 ml syringe into anti-coagulant free plastic tubes, it was allowed to coagulate at room temperature and centrifuged at 3,000 rpm for 5 min. The supernatant serum was stored in a freezer for subsequent biochemical analysis. The serum biochemical parameters that were analyzed included total protein, albumin, globulin glucose, aspartate aminotransferase (AST), alanine aminotransferase (ALT) and alkaline phosphatase (ALP). The total protein was determined using Biuret method (Tietz, 1995), while albumin level was determined by the Bromocresol green method (Toro, 1975). The ALT and AST activities were determined according to the methods of (Rej and Hoder, 1983). The ALP activity was determined by the method of (McComb *et al*., 1983). The biochemical analyses were carried out at Veterinary Teaching Hospital, Ahmadu Bello University, Zaria, Kaduna state.

Statistical Analyses

All data obtained were statistically analyzed using the analysis of variance while the significant differences in means were separated using pair wise-difference procedure of SAS (2002)

RESULTS AND DISCUSSION

The effect of taurine on mean serum biochemistry values of WAD sheep investigated in this study is shown in table 2. All the serum biochemistry constituents showed significant differences ($P< 0.05$). The TP value was highest in sheep fed T4 (9.00g/dl) which was statistically similar ($P<0.05$) to sheep fed T3 (8.89g/dl) and diet T2 (8.75g/dl) while sheep fed T1 had the least value (7.89g/dl). This result is similar to the findings of (Zeweil *et al*., 2011) who reported an increase in total protein when taurine was fed to broilers birds. Significant differences ($P < 0.05$) also existed among the means of albumin and globulin. Albumin values ranged from 4.31g/dl (T1) to 4.88g/dl (T3). Globulin values varied from 5.18g/dl (T1) to 6.81g/dl (T3).

Table 2: Effect of Taurine on Serum Biochemistry Values of WAD Sheep

Parameters	T1	T2	T3	T4	SEM
Glucose (mg/dl)	62.11^a	57.84^c	49.63	46.25	0.05
Total protein g/dl	8.11^b	8.75^a	8.89^a	9.00^a	0.13
Albumin (g/dl)	4.31^b	4.41^b	4.88^a	4.47^b	0.15
Globulin (g/dl)	5.68^c	5.83^b	6.81^a	6.31^a	0.22
Aspartate aminotransferase (U/L)	88.53^a	84.51^b	75.25^c	70.88^d	1.13
Alanine aminotransferase (U/L)	33.58^a	29.07^b	24.95^c	24.21^c	0.47
Alkaline phosphatase (U/L)	124.17^a	116.83^b	109.57^c	109.19^s	1.18
Cholesterol (mg/dl)	73.27^a	64.75^b	48.36^c	45.67^d	1.09
Triglycerides (mg/dl)	28.13^a	23.65^b	19.31^c	17.81^c	0.65

The glucose value was significantly affected (P< 0.05) by the dietary treatments. The total glucose recorded varied from 46.25mg/dl (T4) to 62.11mg/dl (T1). However, the glucose concentration decreases with increasing supplementation. This finding is in agreement with Thorstensen *et al.* (2012) who reported a decrease in glucose level of mouse administered with taurine supplemented diet. Taurine control glucose levels improved insulin action. The transaminase enzymes activities (ALT, AST and ALP) were significantly affected (P< 0.\05) by the dietary treatments. values decrease as the inclusion levels of taurine increases in the diet. The decreasing in these enzymes may suggest that there is no liver damage but rather a slowdown of the function of the liver as influenced by the taurine supplementation.

There were significant differences (P< 0.05) in the concentration of cholesterol and triglycerides respectively concentration decreases as the levels of supplementation increases (73.29mg/dl, - 45.67mg/dl and 28.13mg/dl – 17.81mg/dl) respectively. This observation corroborates the findings of (Zeweil *et al*., 2011) who reported that inclusion of dietary taurine decreases plasma total cholesterol and triglycerides on its administration to mice.

CONCLUSION AND RECOMMENDATION

There was an extensive variation in the serum biochemical values for sheep fed the control diet compared to other sheep fed the supplemented diet. The variation can be attributed to the taurine supplemented in the diets. Taurine is an anti- oxidant with immense quality. This study clearly indicates that taurine supplementation has important role in blood constituent of sheep and therefore, can be incorporated in the diet of sheep.

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PERCEPTION OF POULTRY FARMERS ON CLIMATE CHANGE IN KANO STATE NIGERIA

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ABSTRACT
Climate change is a global phenomenon that plays a pivotal role in poultry agriculture. It affects both the broiler chicken and layers in their meat and egg productions respectively. The study was carried out in Kumbotso Local Government Area of Kano State to investigate how poultry farmers perceive climate change. The study also described the socio-economic characteristics of poultry farmers in the study area. A multistage sampling procedure was used to select 120 respondents for the study. Structured questionnaire was used to elicit information from the respondents. Data collected were analyzed using descriptive statistics and Likert scale. The results showed that majority (75.0%) of the respondents were males; mostly were 21-30 years of age (52.5%) and 66.7% had tertiary education. Most of the farmers were married (71.1%). Based on ranking most of the poultry farmers perceived that climate change leads to food shortage for their animals and causes drought; they also perceived that climate change leads to poor performance of animals as well as could cause death of the animals. The study concluded that majority of the farmers were aware that climate change has negative effects on poultry production and understand that the Government is not doing much on mitigation strategies in favour of poultry farmers. Therefore, it was recommended that Government should formulate policies to help farmers mitigate the impact of climate change on their farms. Sensitization on mitigation strategies should be carried out and the awareness should be sustained by extension workers in Kumbotso.
Keywords: *Climate Change, Disease, Management, Perception, Poultry Agriculture*

INTRODUCTION
The need for animal protein is always rising, with meat consumption expected to rise by 76% globally between 2015 and 2050 (WRAP Food Futures, 2015). Livestock farming is a fundamental activity for maintaining the current society. By 2050, the world's population is expected to reach 9.1 billion people. As a result, agricultural activities must grow accordingly in order to sustainably meet this growing food demand (Elverfeldt *et al.*, 2 010). Ruminant livestock, such as cattle, sheep, and goats, are essential for global food security and play a crucial role in agricultural economies worldwide (Beauchemin *et al.*, 2020). Non-ruminant Livestock such as poultry also plays a significant role in agricultural economy. However, one major environmental challenge associated with livestock production is the significant production of potent greenhouse gas (GHG) that contributes to climate change (Knapp *et al.*, 2014). GHG concentrations in the world have increased rapidly since pre-industrial times due to human activities, with negative effects on the climate (Intergovernmental Panel on Climate Change, 2013). Methane emissions from ruminants account for a significant proportion of global GHG emissions, making it crucial to address this issue to reduce the environmental impact of livestock agriculture (Beauchemin *et al*., 2020). Climate change is an indefinite continuous variation in the mean of climate parameters (temperature, rainfall, humidity and soil moisture) due to change in decomposition of atmospheric gases. Krishna (2011) stated that the change in atmospheric composition is attributed to the emission of GHG such as carbon dioxide (CO_2), Methane (NH_4), Nitrogen oxide (N_2O) and other gases. Climate variation is a shift in the average weather that a given area experiences. It occurs over a period of time which may range from several decades to centuries. It has been observed across the globe that there has always been a change in the climate of an area for a period of 30-100 years manifesting in earthquakes, flooding, tsunami, tornadoes, fluctuations in rainfall and temperature.

Intergovernmental panel on climate change (2013) made it certain that climate variation is taking place. Climate change is a global issue because it does not affect the poor and developing countries alone but is also facing the developed world with flooding, earthquakes, cyclones, tornadoes and wild fires. It is clear that climate variation in many parts of the world adversely affect socioeconomic sectors which include water resources, agriculture, forestry, fisheries and animal husbandry. It is a phenomenon that will continue to occur; mitigating it is the only way out. Agriculture is responsible for 14% of global GHG emissions and livestock variation plays a considerable role in climate variation in terms of their contribution to GHG emissions (Steinfeld *et al.,* 2006; Krishna, 2011). The greatest effects of climate variation have however been predicted to be in animal production in sub-Saharan African which include Nigeria (Adesoji and Famuyiwa, 2010). Livestock accounts for 40% of agricultural gross domestic product (GDP) and employs 1.3 billion of people while supporting the live hoods of one billion of the worlds' poor (food and agricultural organization, 2007). Poultry production is a major source of protein which has empowered poultry farmers to secure a means of survival and livelihood. Climate variation affects poultry production by reducing poultry yield and nutritional quality of feeds, increasing disease and disease-spreading pests, reducing water availability and making it difficult for birds to survive (Spore, 2008).
There is the need for the farmer to have understanding of climate change. A farmer having adequate knowledge of climate change and good perception of the effects on his/her poultry production can allow the farmer to take necessary precaution in planning ahead to minimize loss or even to use it for his or her advantage. Many findings had been done on climate change but there is little empirical evidence on the perception of farmers on the effects of climate change on poultry production, hence this study focused on investigating the perceptions of farmers on the effects of climate change on poultry production in Kano state, Nigeria.

MATERIALS AND METHODS

The study was carried out in Kumbotso Local Government Area (LGA) of Kano State. Primary data were obtained by administering structured questionnaire to poultry farmers in the study area by trained enumerators. A total of 120 farmers were involved in the study. Mean, frequency distribution and percentages and five-point Likert scale were employed to analyse the data. Farmers' perceptions on the effect of climate change on poultry production were measured as strongly agree (SA) agree (A), undecided (U), disagree (D) and strongly disagree (SD) which were scored 5, 4, 3, 2, and 1 respectively. Decision rule was based on perception mean that was equal to or greater than three as being a very serious (VS) perception while less than three is considered not serious (NS).

RESULTS AND DISCUSSION

Socio-economic Characteristics of Respondents

Table 1 elucidates that most of the respondents were aged between 21-30 years. This age group makes up about 53% of the total sampled respondents, 33.3% of them were aged between 31-40 years old, 13.3% of the respondents are between the range of 41-50 years while few. 8.0.% of the respondents are between 10-20 years old. These attributes show that the sampled respondents are youths which make them active in poultry production. Taru *et al.* (2008), opined that eligibility of one's performance in certain activities or role including agricultural activities is determined by the age and too young or too old people are generally inactive or of low productivity on the farm. 75% of the respondents were male while 25% of the respondents were female. This implies that majority of the farmers in the study area were male. Furthermore, most of the respondents were educated with 66.7% having attained tertiary education. On marital status, the distribution elucidates that 71.00% of the respondents were married adults and 20.0% are single and 8.00% divorced. This result agrees with the finding of Alade and Ademola (2013) which reported that larger respondents' percentage (73.3) were married. About 73 % of the sampled respondents were on poultry farming full time. The implication of this is that their sole source of income was poultry farming. 10% were civil servants and traders respectively while others were 6.7%. The mean household size for the area was 5, majority (65.0%) of the respondents have household size of about 1-5 persons per family, however 30.00% had between 6-10 household members and about 8% had between 11-15 persons per family. The year of experience of the respondents in poultry farming varies. The largest percentage (68.3%) of the respondents had been in poultry farming for a long period of more than 10 years, implying that the poultry farming has been able to support their livelihood for a long time and they have been through the poultry farming for long so it may be difficult to leave the farming for another new field or trade entirely.

Perception of poultry farmers on climate change

The results in Table 2 showed the perception of poultry farmers on climate change. The results were ranked using the mean of each perception. The statement climate change leads to food shortage for their animals ranked 1st with a means of 4.23. The statement climate change leads to drought ranked 2nd with a means of 3.97. The statement climate change leads to death of animals and the statement climate change leads to poor performance of animals in terms of meat and egg production and climate change leads to death of animals ranked 3rd with a means of 3.77. The statement climate change leads to increase in temperature which increase the heat stress of the animals ranked 5th with a means of 3.76. The statement climate change leads to reduction in the feed intake of the animal ranked 6th with a means of 3.68.

Table 1: Socio-economic variables of respondents

Variables	Frequency	Percentage
Age		
10-20	1	0.9
21-30	63	52.5
31-40	40	33.3
41-50	16	13.3
Mean age		
Gender		
Female	30	25.0
Male	90	75.0
Level of education		
Primary education	10	8.3
Secondary education	30	25.0
Tertiary education	80	66.7
Marital status		
Single	24	20.0
Married	86	71.7
Divorced	10	8.3
Source of Capital		
Personal savings	65	54.2
Friend	22	18.3
Family	25	20.8
Bank loan	8	6.7
Occupation distribution		
Trader	12	10.0
Poultry farmer	88	73.3
Civil servants	12	10.0
Others	8	6.7
Household size		
1-5	78	65.0
6-10	32	26.7
11-15	10	8.3
Years of experience		
1-5	58	48.4
6-10	49	40.8
11-15	13	10.8

Source: Field Survey 2023

Table 2: Perception of poultry farmers on climate change in Kumbotso LGA of Kano State

ACTIVITIES	VS	S	UD	LS	NP	N (120)	MS	Rank	Remark
Climate change leads to Government policy in favour of Farmer	6	7	1	20	86	187	1.56	10th	Not Serious
Climate change leads to shortage of food for their animals	66	38	4	5	7	511	4.23	1st	Very Serious
Climate change leads to poor performance of animals	34	56	8	12	10	452	3.77	3rd	Very Serious
Climate change leads to low income for farmers	4	16	18	58	24	278	2.32	8th	Not Serious

Climate change leads to increase in temperature which increase the stress of the animal	5	10	1	79	25	451	3.76	5th	Very Serious
Climate change leads to death of animals	19	76	5	18	2	452	3.77	3rd	Very Serious
Climate change leads to loss of jobs by farmers	5	15	9	45	26	228	1.90	9 th	Not Serious
Climate change leads to outbreak of disease	10	15	18	42	35	283	2.36	7th	Not Serious
Climate change leads to reduction in the feed intake of the animal	45	52	3	15	5	477	3.97	2nd	Very Serious
Climate change lead to drought	42	38	10	20	10	442	3.68	6th	Very Serious

Source: Field survey, 2023

This agrees with Elijah and Adedapo (2006) research in which it was stated that majority of his respondents agreed that high temperature makes birds feed less. The statement climate change leads to outbreak of diseases ranked 7th with a means of 2.36. The statement climate change leads to low income for farmers ranked 8th with a means of 2.32. The statement climate change leads to loss of job by farmers ranked 9th with a means of 1 .9. The statement climate change leads to policy formulation by the government in favour of farmers for mitigation strategies ranked 10th with a means of 1.56. This means that majority of the farmers strongly disagree with the fact that government is doing anything in terms of policy making to help the farmers ameliorate the effect of climate change on their poultry production.

CONCLUSION AND RECOMMENDATION

It was concluded that that the majority of the farmers were aware that climate changes has negative effect on poultry production, and understands that the Government is not doing much on mitigation strategies in favour of poultry farmers It was recommended that more awareness and sensitization on the effect of climate changes on poultry production should created and the engagement of extension workers should be encouraged, the Local Government should also formulate policies to help farmers mitigate the impact of climate change on their farms Also more extension workers should be engaged to train and educate farmers on climate change.

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EFFECT OF FEEDING COMPOSITE SWEET POTATO (*IPOMEAN BANTATA*) MEAL ON GROWTH PERFORMANCE OF BROILER CHICKENS

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ABSTRACT

A total of one hundred and twenty (120) day-old Abor Acre strains broiler chickens were used in a feeding trial to determining the effect of feeding composite sweet potato (umuspo 4 or solo gold) meal on the growth performance of broiler chickens. Four roughly isonitrogenous diets containing 2915.50, 2861.73, 2792.70 and 2741.92 Kcal/kg ME were used respectively for the study in a completely randomized design. Feed and water were provided to the chickens ad libitum for eight weeks. The results of the proximate composition of composite sweet potato meal revealed that the crude protein (11.31%), crude fibre (9.71%), Ether extra (1.25%), Ash (8.14%), Moisture content (9.85%) and NFE (59.75%), Total feed intake and average feed intake followed similar trend, with broiler chickens fed diets I, II and III statistically similar but significantly different from broilers fed diet IV. The feed conversion ratio of $diet_{III}$ (1.81) compared favourably with $diet_{I}$ (1.66) but statistically different ($P<0.05$) from $diet_{II}$ (2.04) and $diet_{IV}$ (2.24). Decreasing feed production cost (₦/kg) (380.00, 375.48, 370.96 and 366.44) was observed as inclusion level of composite sweet potato meal increased from 0 to 30%. The carcass /organ weights of broilers fed diets containing varying levels of composite sweet potato meal did not significantly differ among the broiler chickens. Biochemical and haematological indices of broiler chicken fed diets containing varying levels of composite sweet potato meal did not significant vary in packed cell volume, haemoglobin, albumin and alkaline phosphate. Inclusion of composite sweet potato meal up to 20% was apparently better tolerated by the broiler chickens in all the parameters evaluated.

Keywords: *Broiler growth, carcass, organ weight, blood profiles, sweet potato*

INTRODUCTION

Presently poultry/livestock production cannot supply the projected animal protein requirements of the population of Nigeria. The food and agricultural organization (FAO, 2000) report on livestock productivity (i.e. yield in kg/head) showed a drop in the production of animal protein from livestock sources. The production of livestock and livestock products has been declining steadily since 1965, and the percentage decline from year to year has been estimated at over 2% (FAO, 2000). The several challenges facing the poultry industry in the tropics is feed availability and it remains the most pressing (Girma *et al*., 2011). Hence, the need to search for alternative sources to bridge the gap created by the inadequate supply of these expensive conventional protein and energy sources. One possible source of cheap feedstuff is the use of composite sweet potato meal in broiler chickens diet. Sweet potato is a short season plant that can be grown three to four time in a season and the productivity is high if well managed thereby producing the feed needed to rear broiler chickens and/or human needs. Sweet potato leave/vines and the unsalable tuber are common during harvest season and off-season and most common in areas with high potential of producing sweet potato. This study therefore was undertaken to evaluate the proximate composition, best dietary level of inclusion of composite sweet potato meal on carcass/organ weight, haematological and blood chemistry of broiler chickens.

MATERIALS AND METHODS

Experimental Site

The research was conducted at the Poultry Unit of the Teaching and Research Farm of Michael Okpara University of Agriculture, Umudike, Abia State. Umudike lies on latitude 05^0 29'N and longitude 07^0 33'E with an elevation of 122 m above sea level and is located in the tropical rainfall zone of Nigeria. This zone is characterized by annual rainfall of about 2177mm, monthly ambient temperature range of 22^{0}C – 36^{0}C and relative humidity of 50 – 95% depending on the season and location (NRCRI, 2018).

Management of experimental birds

One hundred and twenty day old Abor Acre strains of broiler chickens were assigned in a completely randomized design to four treatment groups with three replicates of ten birds per replicate. The formulated straight broiler diets were used for the period of eight weeks (56 days). Feed and water were provided *ad libitum.* Proper sanitation, routine medication and normal vaccination were maintained to prevent any outbreak of disease.

Processing of composite sweet potato meal

Sweet potato (Umuspo 4 or Solo Gold) tubers and foliage were obtained from NRCRI Umudike used in the research. The test ingredient was made from Umuspo 4 (solo gold) a cultivar of sweet potato. The leaves/vines and tuber were harvested, processed (i.e. cut, chopped, sun dried for four days and hammer milled and combined at a ratio of 1:1:3 to form the composite sweet potato meal.

Proximate compositions and gross energy of the composite sweet potato meal

Samples of the test materials were analyzed for, proximate constituents according to the methods described by AOAC (2005) while the gross energy was determined using Adiabatic Oxygen Bomb Calorimetric technique.

Experimental diets

The composite sweet potato meal was included in the diets at 0, 10, 20 and 30%. Treatment 1 was the control diet having maize as the major energy source. The ingredients and composition of the experimental diets were as shown in Table 1 below: The formulated straight broiler diets were used for the period of eight weeks.

Experimental Design and Statistical Analysis

The experiment layout was completely randomized design using four treatments with three replicates of ten birds each. All data collected were subjected to analysis of variance (Steel and Torrie, 1980), and significant differences between treatments means were separated using Duncan's multiple range test (Duncan, 1955).

Carcass Characteristics and Organ Proportions

The carcass characteristics and organ proportions were determined by slaughtering three birds per treatment at the end of the feeding trial. The birds slaughtered were fasted for 24 hours to empty the digestive tract but drinking water was offered. Slaughtering was done by a clean cut across the jugular Vein and the birds were allowed to bleed for at least three minutes. The birds were de-feathered by dipping into boiling water for one and a half minutes and then the feathers were removed. The carcass was cut into parts and the organs separated according to the procedure described by Ojewola and Longe (1999). All parts (breast, drumstick and thigh) were weighed and expressed as percentage dressed weight. Organs like liver, heart and gizzard were also weighed and expressed as percentage of live weight.

Value of cut-parts and organs expressed as % dressed weight,

$$\text{Cut parts} = \frac{\text{Thigh / drumstick / breast cut/back cut}}{\text{Dressed weight}} \times \frac{100}{1}$$

$$\text{Organs} = \frac{\text{Heart / liver / Intestine / Proventriculus}}{\text{Dressed weight}} \times \frac{100}{1}$$

Blood Examination

At the end of 56 days of experiment, 3 and 4 blood samples were drawn from two birds per replicate through the Jugular vein using a 12 ml gauge (6 cm) needle to draw 10ml of blood. The blood samples were divided into two: first lot (5 ml) was emptied into heparin packs containing about 40 mg of anti coagulant to determine the haematological components. The second lot (5 ml) was collected over anti-coagutant free bottles, and was used to determine blood biochemical components. These samples were used to determine hematological parameters such as packed cell volume (PCV) white blood cells (WBC), WBC differentials and hemoglobin count (Hb).

RESULTS AND DISCUSSION

Table 1 shows the compositions of the study diets. The diets were isonitrogenous and the energy content decreased across the treatments, as composite sweet potato meal increased in the diet. The crude fiber content increased with increase in the inclusion levels of composite sweet potato meal in the diet. The chemical composition of composite sweet potato meal is presented in Table 2, it was as follows crude protein (11.31%), crude fibre (9.71%), ether extract (1.25%), Ash (8.14%), moisture content (9.85%) and NFE (59.75%). Table 3 showed the total feed intake and average feed intake followed similar trend, with broiler chickens fed diets I, II and III statistically similar but significantly different from broilers fed diet IV. This may be due to high fibre level of the diet as represented on the feed composition. More so, birds on diet IV recorded higher crude fibre (CF) many nutritionist have considered that the requirements of broiler for crude fiber (CF) are low and recommended to reduce it in diets for broiler chickens to less than 3.0-4.0% depending on the age (Swennen *et al*., 2010). Janssen and Carrc (1985) indicated that fribrous components of the food had negative effects on growth performance of the broiler chickens. The feed conversion ratio of diet_{III} (1.81) compared favourably with diet_{I} (1.66) but statistically different ($P<0.05$) from diet_{II} (2.04) and diet_{IV} (2.24).

Table 1: The percentage composition of experimental diets

Ingredients	**T1 (0%)**	**TII (10%)**	**TIII (20%)**	**TIV (30%)**
Maize	55.96	50.36	44.77	39.18
Composite sweet potato meal	-	5.6	11.19	16.78
Soya bean meal	14.50	14.50	14.50	14.50
Groundnut cake (GNC)	11.84	11.84	11.84	11.84
Fish meal	2.00	2.00	2.00	2.00
Wheat offal	12.00	12.00	12.00	12.00
Bone meal	2.50	2.50	2.50	2.50
Lime stone	0.50	0.50	0.50	0.50
Vitamin premix*	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10
Total	**100**	**100**	**100**	**100**
CP%	20.00	20.50	20.80	21.10
CF%	3.76	5.06	5.70	6.21
ME.Kcal/kg	2915.50	2861.73	2792.70	2741.92

*****Provide the following per kg of feed: Vit A 10 000 000 iu; Vit D3 2 000 000 iu; Vit B1 0.75 g; Vit B2 5 g; Nicotinic acid 25 g; Calcium pantothenate 12.5 g; Vit B12 0.015 g; Vit K3 2.5 g; Vit E 25 g; Biotin 0.05 g; Folic acid 1 mg; Choline chloride 250 g; Co 0.4 g; Cu 8 g; Mn 64 g; Fe 32 g; Zn 40 g; I 0.8 g; Flavomycin 100 g; Spranycin 5 g; 3-Nitro 50 g; DL-Methionine 50 g; Se 0.16 g; L-Lysine 120 g; BHT 5 g.

Table 2: Proximate composition of test ingredient

Composition (g/100gdm)	Composite sweet potato meal
Crude protein	11.31
Crude fibre	9.71
Lipids/fat	1.25
Moisture content	9.85
Ash	8.14
NFE	59.75

Table 3: Growth Performance of broiler chicken fed diets containing varying levels of composite sweet potato meal.

Parameters	D_I	D_{II}	D_{III}	D_{IV}	SEM
Initial weight (g)	42	42	41	42	0.58
Final Weight (g)	2382.23^a	2016.67^b	2176.77^a	1629.87^c	65.09
Weight gain (g)	2340.23^a	1974.67^{ab}	2135.77^a	1587.87^b	33.33
Total Feed Intake (g)	5423.88^a	5550.08^a	5563.87^a	5117.96^b	90.48
Average weight (g)	40.35^a	34.04^b	36.82^a	27.38^c	1.16
Average Feed Intake (g)	66.53^{ab}	69.37^a	68.54^a	62.70^b	1.55
Feed Conversion Ratio	1.66^b	2.04^a	1.81^b	2.24^a	0.22
Cost/ Kg Feed (₦)	380.00	375.48	370.96	366.44	-

^{abc} Means along the same row with different superscripts are significantly (P<0.05) different.
SEM: Standard error of mean: D_I: $Diet_I$: D_{II} : $Diet_{II}$: D_{III} : $Diet_{III}$ and D_{IV}: $Diet_{IV}$

Decreasing feed production cost (₦/kg) (380.00, 375.48, 370.96 and 366.44 naira) was observed as inclusion level of composite sweet potato meal increased from 0 to 30%. Table 4 reveals the carcass /Organ Weights of Broilers fed diets containing varying levels of composite sweet potato meal. There were no significant differences among the broiler chickens fed the various diets in breast cut, drumstick, thigh cut, back cut and heart. The percentage liver weight and gizard showed significant differences and $diet_{II,}$ $diet_{III,}$ and $diet_{IV}$ were larger than the control $diet_I$ this is in line with the findings of Ukachukwu (2000) who said that the presence of anti-nutritional factors cause the enlargement leading to increase in weight of liver due to detoxifying activities and also the increase in the size of gizzard could be attributed to increase in the quantity of less digestible fibrous materials in the diet (Akinmutimi *et al.*, 2006). In the abdominal fat, broiler chickens fed; $diet_I$ (1.21%) was significantly higher (P<0.05) than broiler chickens fed $diet_{II}$ (0.15%), $diet_{III}$ (0.19%) and $diet_{IV}$ (0.12%). This could be attributed to increase in metabolic activities of the various organ on fibre in the diets which in turn helps to burn down the abdominal fat. Table 5 presents the Biochemical and haematological indices of broiler chicken fed diets containing varying levels of composite sweet potato meal. There were no significant differences in packed cell volume, haemoglobin, albumin and alkaline phosphate. The red blood cells (RBC) count differed significantly ($P < 0.05$), broilers fed diet$_{III}$ was statistically similar to all the broilers fed the various diets. The reduction in the RBC and WBC in broiler chickens fed diet$_{IV}$ can probably be due to the combined effects of anti nutritional factors. Since all the blood parameters were within normal range as reported by Mitruka and Rawnsely (1977), the observed differences in red blood cell, white blood cell and total protein may be due to slight differences in the individual broiler chickens. This trend can be buttressed by the fact that the formed element of blood component cannot be easily altered by nutrition but by disease and genetic makeup of individual animals (Tijani *et al*., 2015).

Table 4 Carcass /Organ Weights of Broilers fed diets containing varying levels of Composite Sweet Potato Meal.

Parameters	D_I	D_{II}	D_{III}	D_{IV}	SEM
Breast Cut	33.85	32.96	29.57	29.95	1.30
Drumstick	15.41	15.43	16.22	15.39	0.68
Thigh Cut	16.64	15.86	16.99	16.62	0.57
Back Cut	21.40	21.22	24.02	21.54	1.47
Heart (%)	0.57	0.63	0.63	0.73	0.06
Liver (%)	2.20^b	2.82^a	2.38^b	2.78^a	0.09
Gizzard (%)	1.94^c	2.38^b	2.40^b	2.73^a	0.04
Abdominal Fat(%)	1.21^a	0.15^b	0.19^b	0.12^b	0.09

^{abc} Means along the same row with different superscripts are significantly ($P<0.05$) different.
SEM: Standard error of mean. D_I: Diet$_I$: D_{II} : Diet$_{II}$: D_{III} : Diet$_{III}$ and D_{IV}: Diet$_{IV}$

Table 5: Biochemical and Haematological Indices of Broiler Chicken Fed diets containing varying levels of Composite Sweet Potato Meal

Parameters	D_I	D_{II}	D_{III}	D_{IV}	SEM
Total Protein (g/dl)	3.62^a	3.06^b	2.95^b	2.93^b	0.40
Albumin (g/dl)	1.50	1.35	1.44	1.37	0.06
Alkaline phosphate (ALP) IU/L	180.57	180.77	194.69	195.69	14.11
PCV (%)	29.33	29.67	29.50	28.67	0.69
HB(g/dL)	6.42	6.36	6.30	5.90	0.17
RBC($x10^6/\mu L$)	2.66^a	2.70^a	2.34^{ab}	2.18^b	0.12
WBC ($x10^3/\mu L$)	8.36^a	7.96^a	7.74^a	5.93^b	0.30

^{abc} Means along the same row with different superscripts are significantly ($P<0.05$) different.
SEM: Standard error of mean. D_I: Diet$_I$: D_{II} : Diet$_{II}$: D_{III} : Diet$_{III}$ and D_{IV}: Diet$_{IV}$. PCV: Packed cell volume. HB: Haemoglobin. RBC: Red blood cells. WBC: White blood cell. ALP: Alkaline phosphate

CONCLUSION AND RECOMMENDATIONS

The results showed that the best dietary level of inclusion of composite sweet potato meal in broiler chickens is 20%. Therefore, composite sweet potato meal may be utilized in broiler chickens production.

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INFLUENCE OF MORINGA LEAF MEAL AS FEED ADDITIVE ON GROWTH PERFORMANCE OF BROILERS

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ABSTRACT
This study was carried out to determine the effect of processed Moringa oleifera leaf meal as a feed additive on growth performance and carcass attributes of broilers. For this purpose, 240 day-old unsexed broiler chicks were randomly allocated to four treatment (iso-caloric and iso-nitrogenous) diets consisting of 0 Moringa oleifera leaf meal (T_1), 250g Moringa oleifera leaf meal (T_2), 500g Moringa oleifera leaf meal (T_3) and 750g Moringa oleifera leaf meal (T_4), each inclusion per 100 kg of diet. The four different graded levels of Moringa oleifera leaf meal were used to formulate poultry feed using soya bean and yellow maize for broiler starter (20% crude protein) and broiler finisher (18% crude protein) using Pearson Square Method. The experiment was carried out in a CRD with the birds distributed into 4 replicates comprising 60 chickens per replicate. Feed consumption, weight gain and feed conversion ratio were recorded to evaluate the growth performance of the birds. At the end of experimental period, the birds were weighed to obtain live body weight, then slaughtered and weighed to get data for carcass quality. The results showed a significant ($p<0.05$) variation in the mean final weight (provide the values), weight gain (provide the values) and feed intake (provide the values) among treatment groups at four weeks of age. However, no significant difference was observed in initial body weight and feed conversion among treatment groups at 28 days. In addition, except for initial body weight, statistically significant variations were observed in all the growth characteristics evaluated in the birds at eight weeks of age. The study indicated that supplementation of diet with moringa leaf meal up to 750g may not have significant influence on growth characteristics of broilers.
Keywords: *Moringa oleifera, broiler chicks, growth performance, weight gain, feed conversion*

INTRODUCTION
The poultry industry contributes significantly in provision of animal proteins in the human diet (Abdulsalam *et al*., 2015). When compared to beef industry, poultry enjoys a relative advantage of ease of management, higher turnover, quick returns to capital investment and wider acceptance of its product for human consumption (Haruna and Hamidu, 2004). Broiler chicken is one of the most important animal protein sources to human diet due to its relatively faster growth rate and shorter life cycle compared with other meat-producing livestock. Numerous studies have shown that the growth of broiler chicken, is dependent on the proper development of its gastro intestinal tract (Dibner and Richards, 2005). The nature of the bird's metabolism and its digestive system has necessitated the addition of appropriate supplements to its feed, to encourage a very high and fast growth and ultimately improve the production performance of the chickens.

Consequently, chemically based feed additives, such as antibiotics and growth promoters, have been widely used in the broiler industries to improve health and productivity of chicken flocks (Murugesan *et al*., 2015). Furthermore, birds raised with these feed additives have been shown to achieve good performance with improved quality products (NOAH, 2001). However, despite the positive impact of these feed additives on growth and development of the birds, there are reports that these feed additives may still remain in the broiler products as residues which may have negative effects on consumer's health (Donoghue, 2003). The use of natural herbs as viable alternatives to antibiotics in poultry production has been reported. For instance, Movahhedkhah *et al*. (2019) reported the growth-promoting roles of dietary inclusion of herbs and their extracts in poultry birds.

Research has shown that *Moringa oleifera* L. is a promising natural herb that could enhance the production performance and health status of birds as an alternative to antibiotics and growth promoters. The *M. oleifera* is a tropical plant native to Asia, belonging to the genus Moringa and family Moringaceae. Moringa is a popular multipurpose tree, naturally cultivated in tropical and subtropical countries, due to its considerable inherent nutritional, antioxidant, and phytochemical benefits, as well as its ability to survive in diverse climatic conditions. It is one of the most promising crops enriched in micronutrients with good antioxidant potential that ultimately strengthen immune system (Yang *et al.*, 2007). It was suggested that *M. oleifera* is a potential plant that could be used to enhance immune response and to improve the intestinal health of broiler chickens (Anwar *et al*., 2007). Along with that, it has high quality protein comprised of significant quantities of all the essential amino acids (Foidl and Paull, 2008). This study was conducted to assess how different levels of supplementary *M. oleifera* leaf meal (MOL) may affect the performance of broilers and to explore the potential benefits of MOL in the diet of broiler chickens.

MATERIALS AND METHODS

The experiment was carried out in an open mesh sided, deep litter poultry house of the Department of Agricultural Technology, Kaduna Polytechnic, Kaduna. The house was cleaned, washed and disinfected using formalin and folic acid. Each pen floor was covered with enough wood shavings with allocation of one tubular feed + trough and one round fountain drinker. Two hundred and forty unsexed day-old Zam strain broiler chicks were purchased from a local hatchery and randomly allotted into 16 pens (four groups) of 15 chicks in a pen, in a completely randomized design. The chickens were allocated to four diets which were formulated with various levels of supplemental *M. oleifera* leaf meal (250, 500 and 750 g per 100 kg diet as treatments 2, 3, and 4, respectively) in addition to a control diet (treatment 1) without *M. oleifera* inclusion.

Fresh mature *M. oleifera* plants was sourced from a local market within Kaduna metropolis. The leaves of the plant were removed from the stems, sorted, cleaned with tap water, and dried under shade for 2 days. Four diets were formulated for both the broiler starter and broiler finisher phases. The experimental diets were made iso-caloric and iso-nitrogenous and formulated to meet the National Research Council requirements of broiler chicks (NRC, 1994). The diets were also formulated to meet all the bird’s dietary nutrient requirements with the starter and finisher diets containing, respectively, table 1. Both diets had a metabolizable energy of 3,200 kcal/kg and 3,100 kcal/kg and crude protein of 20% and 18.79%, respectively and were supplemented with vitamins, minerals and amino acids.

Table 1. Composition and nutrient content of broiler starter and finisher diets (air-dry basis, %)

Ingredient	Starter ration (%DM)	Finisher ration (%DM)
Maize	53.45	63.40
Soya bean cake	27.50	17.40
Groundnut cake	10.00	10.00
SOS	5.00	5.00
Limestone	0.50	0.50
Born meal	2.80	2.80
Common Salt	0.23	0.23
Vitamin-mineral Premix*	0.24	0.24
Methionine	0.20	0.20
Lysine	0.05	0.20
Enzyme	0.03	0.03
Mobilizing energy (Kcal/kg)	2894.00	2978.07

DM- Dry Matter * Biomix premix supplied per kg of diet

Two hundred- and forty-day-old Zam strain broiler chicks of mixed sexes were sourced from commercial poultry firm and used for the experiment. Sixty chicks were housed for each of the four dietary treatments (with graded levels of *M. oleifera* leaf meal) compared, with three pens per treatment as replicates and fifteen birds in each replicate using completely randomized design. Each pen was provided with aluminum pan feeders (300 mm) and mini plastic drinkers of the same size (300 mm). The broiler chicks used for the study were raised in deep litter and brooded for the first one week in an electrically heated battery brooder cage. Routine management, vaccination and medication were carried out as at when due, and all the possible steps were taken to avoid animal suffering at each stage of the experiment.

The chicks in groups and feeds were weighed weekly according to cage numbers using insert table or sensitive scale. Gain in body weight, feed consumption, average daily gain and feed conversion efficiency of the chicks were recorded at the beginning of each week, starting from placement until slaughter. Then the carcass and liver were weighed. In addition, the proximate analysis for the chemical components of *M. oleifera* leaf meal (dry matter, crude protein, phosphorus, crude fiber, ME, ash and nitrogen free extract) were determined according to

AOAC (2000) and results presented in Table 2. All the data collected were analyzed statistically using one-way analysis of variance according to Steel and Torrie (1981) and means were compared using Duncan's multiple-range test. Statistical significance was determined at P<0.05. The analysis was carried out using statistical analysis system (SAS, 2005) program.

Table 2: Nutrient composition of *Moringa oleifera* leaf meal (dry matter basis)

Parameter	Composition (%)
Dry matter	82.80
Crude protein	27.60
Crude fibre	16.7
Phosphorus	0.80
Ash	3..30
Moisture	7.31

RESULTS AND DISCUSSION

Growth performance (0 to 4 weeks)

The effect of feeding *M. oleifera* leaf meal supplemented diet on growth performance of broiler during grower period (0 to 4 weeks) is presented in table 3. The result showed that there was a statistically significant (p<0.05) variation in growth performance with respect to final body weight (provide the values), weight gain (provide the values) and feed intake (provide the values). The moringa supplemental treatment has an increase in these parameters compared to the control diet without moringa. The positive effects of dietary MOL supplementation on animal performance have been previously observed in broilers and laying hens (Lu *et al*., 2016). In addition, it was found that the differences in initial weight gain (provide the values) and feed conversion (provide the values) were not significant. Contrary to this observation, dietary MOL supplementation was reported to decrease body weight and average daily gain (P<0.01), and increased feed conversion ratio (P < 0.001) in experiment conducted by Cui *et al*. (2018).

The data also indicated that the highest live body weight of 1,012.82 g/bird was recorded in diet containing 500 g *M. oleifera* that was statistically comparable to the control diet and significantly higher than other moringa supplemented feeds. This finding is in line with the work of Khan *et al*. (2017), who recorded higher body weight when moringa leaf powder was used as a dietary supplement at 12% in broilers. Similarly, the chickens fed 500g moringa inclusion per kg broiler feed recorded the highest mean weight gain of 969.61 that was statistically at par with all treatment groups except those fed 750g *M. oleifera* supplemented diet. Previous work conducted by Abdulsalam *et al.* (2015) with moringa leaf meal as a supplement in broilers found significant increase in weight gain and a positive effect on growth performance at finisher period.

It is noteworthy, that the feed consumed by birds fed with no moringa leaf meal supplement (control diet) was found to be statistically at par with the other treatment groups. The highest feed intake of 1,609.54 g/bird was obtained with the supplementation of moringa leaf meal at 500 g which was significantly higher than the least (1,489.69 g/day) observed with moringa supplemented diet at 250 g. Contrary to this finding, no significant difference in feed intake and body weight gain was observed between control diet and 25% level of moringa supplementation of conventional soybean meal in broiler diets in a trial carried out by Gadzirayi *et al*. (2012). Furthermore, the result indicated that there was no significant difference among all the treatment groups in terms of feed conversion ratio. This observation is at variance with the finding of Gakuya *et al*. (2014) who reported that feeding broilers with moringa leaf meal resulted in a lower feed intake and a high FCR attributed to the presence of anti-nutritional factors in moringa leaves.

Table 3. Growth characteristics of broilers at 0 to 4 weeks fed moringa leaf meal as feed additive

Parameters	Different levels of moringa leaf supplement				P-Values	
(Gram/bird)	0	250	500	750	Sign.	SEM
Initial weight	44.44	44.44	44.47	45.12	NS	0.23
Final weight	992.67^{ab}	943.33^{bc}	1012.83^{a}	928.53^{c}	*	22.57
Weight gain	947.97^{ab}	898.66^{abc}	969.61^{a}	883.15^{bc}	*	22.58
Feed intake	1,571.33^{ab}	1,489.69^{b}	1,560.60^{ab}	1,609.54^{a}	*	29.34
Feed conversion ratio	1.65	1.86	1.65	2.10	NS	0.05
Mortality rate (%)	0.00	0.00	0.00	0.00	"	"

Means in the same row bearing different subscripts are significantly different (P<0.05): * = Significant; NS = non-significant.

Growth performance (4 to 8 weeks)

The influence of *Moringa oleifera* leaf meal on the growth performance of broilers between 4 and 8 weeks is presented in table 4. The data showed that except for the initial body, all the growth performance attributes of the birds differ significantly (P<0.05) probably due to the application of the treatments in the experiment. Previous studies conducted by Briones *et al*. (2017), demonstrated that moringa leaves can be applied as a dietary supplement in layers and broilers for high production performance and improved eggs quality.

This result showed that broilers fed 750 g *Moringa oleifera* leaf supplement per kg had an average final body weight (3,101.82 g) and mean weight gain (2,202.55 g) which were significantly higher than those of the birds fed 500g moringa supplements and at par with the final weight and weight gain of broilers fed 250 g moringa leaf supplements and the control diet without moringa supplement. A 35-day poultry feeding trial conducted by (Ebenebe *et al.*, 2012) observed higher final live weight, average weight gain, and FCR with 10% moringa leaf meal supplemented diets over the control. A similar study carried out on poultry birds found that feeding *M. oleifera* leaf powder improves live weight, body weight gain, dressing percentage, and FCR compared with the control without moringa (David *et al*., 2012).

The control treatment had the highest feed intake of 5,178.55 g/bird that was statistically comparable to feed intake observed in birds fed diets containing 500g and 750g moringa leaf supplements having feed consumption of 5,100.60 g/bird and 5,025.07g/bird, respectively. A similar experiment conducted by Gakuya *et al.* (2014), indicated that feeding broilers with moringa leaf meal as a supplement in diet resulted in a lower feed intake and a high FCR. The result also showed that the chickens receiving 500 g moringa leaf meal treatment had the highest feed conversion ratio (2.81) that was statistically higher than that of the broilers fed 750g moringa leaf supplements (2.58) but significantly (P<0.05) comparable to the feed conversion ratio of the birds in the control group (2.75) and those fed 250g moringa supplement (2.68). It was reported in a previous experiment conducted by Ayssiwede *et al*. (2011) that dietary application of moringa leaf meal up to a level of 24%, had no adverse effects on body weight, average daily weight gain, FCR, mortality, and the weight of organs in broilers compared to the control diet.

As indicated previously, although the growth performance of birds was significantly influenced by supplementing *M. oleifera* leaf meal in the diets, broilers in the treatment groups did not differ statistically with respect to their initial body weight from 4 to 8 weeks. Similar to this finding, Abdulsalam *et al.* (2015) conducted an experiment with moringa leaf meal as a supplement in broilers diets and reported an enhance growth performance at finisher period. Furthermore, inclusion of *M. oleifera* leaves at higher levels (15% and 20%) in broiler diets was observed to result in a higher growth rate and better health status in broilers (Alnidawi *et al*. 2016).

Table 4. Growth characteristics of broilers at 4 to 8 weeks fed moringa leaf meal as feed additive

Parameters	**Different levels of** moringa leaf **supplement**				**P-Values**	
(Gram/bird)	0	250	500	750	Sign.	SEM
Initial weight	898.14	887.84	897.17	870.35	NS	8.02
Final weight	3,077.67^{a}	2,879.53^{bc}	2,813.81^{cd}	3,101.82^{ab}	*	50.57
Weight gain	2,190.97^{a}	2,009.66^{bc}	1,926.92^{cd}	2,202.55^{ab}	*	49.78
Feed intake	5,178.55^{a}	4,982.22^{b}	5,100.60^{ab}	5,025.07^{ab}	*	50.71
Feed conversion ratio	2.75^{a}	2.68^{ab}	2.81^{a}	2.58^{bc}	*	0.06
Mortality rate (%)	0.00	0.00	0.00	0.00	“	“

Means in the same row bearing different subscripts are significantly different (P<0.05): * = Significant; NS = non-significant.

CONCLUSION

This trial has shown the possible use of *Moringa oleifera* leaf meal as an additive in broiler feeds. It could be concluded that supplementation of *Moringa oleifera* leaf meal up to 500 g in the feed may not have effects on growth and productive performance of broilers.

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INFLUENCE OF MORINGA LEAF MEAL ON CARCASS CHARACTERISTICS AND HEMATOLOGICAL PARAMETERS OF BROILERS

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ABSTRACT
The present study was conducted to assess the effect of Moringa oleifera leaf meal as a feed supplement in broiler diets. Two hundred and forty unsexed day-old Zam strain broiler chicks were randomly allotted into 16 pens (four groups) of 15 chicks in a pen, in a completely randomized design. Each group was fed various levels (250g, 500g and 750g as treatments 2, 3, and 4 respectively) of supplemental M. oleifera leaf meal inclusion per 100 kg diet in addition to a control diet (treatment 1) without M. oleifera leaf meal. All rations were designed as iso-nitrogenous and iso-caloric. The broilers were raised for eight weeks. Feed consumption, weight gain and feed conversion ratio were recorded to evaluate the growth performance of the birds. At the end of experimental period, the birds were weighed to obtain live body weight, then slaughtered and weighed to get data for carcass quality (heart, liver and gizzard weight, carcass yield). In addition, blood samples were collected and taken to laboratory for evaluation of hematological attributes. The result showed that with regards to carcass characteristics, the percentages of heart and liver in relation to chicken live body weight did not differ significantly between all the treatment groups. The data further revealed that statistically significant differences (p<0.05) existed between treatments with respect to live body weight, carcass yield and gizzard weight. However, with respect to blood composition, no statistically significant response was observed in all hematological indices of the broilers, except for packed cell volume and white blood cell.
Keywords: *Moringa oleifera, broiler chicks, growth performance, carcass quality, blood samples and hematological attributes*

INTRODUCTION
The poultry sector has seen rapid with constant growth in the previous decades as the global need for food and nutritional security has increased steadily with population growth (Gržinić *et al*., 2023). Intensive poultry farming, which is an optimized production system in high income countries, is fundamental to modern poultry production. However, in low to middle income countries, the poultry system lacks adequate infection prevention measures, veterinary assistance and infrastructure (Kiambi *et al*., 2021; Bamidele *et al*., 2022). One common feature of these two different poultry production systems, is that the producers in such countries often use antibiotics as prophylactics and for growth promotion to increase production and income.
Pharmaceuticals and antibiotics in food have impact on the health of consumers, therefore they are monitored to comply with maximum residue levels, and to ensure that they do not exceed acceptable limits (Chen *et al.*, 2019). The incomplete metabolism of pharmaceuticals in animals, causes them to be detected in many raw meat samples (Davis *et al*., 2018). The presence of antibiotics has been reported at every stage of poultry production, with the drugs detected both in meat samples from slaughter houses and in ready-to-eat products reaching the consumer. Several studies have suggested that despite the ban on the use of antibiotics as growth promoters in European Union countries since 2016, consumers in Europe and other countries are still exposed to pharmaceuticals in chicken meat.
There has been genuine concern regarding the use of antibiotics and growth promoters in the poultry sector. Therefore, greater attention is now directed towards finding alternatives to antibiotics for meat and egg production. Various alternatives to antibiotic growth promoters, such as probiotics and organic acids, are now used

commercially to enhance health status, feed quality and utilization, and production efficiency in poultry (Khan and Naz, 2013; Khan *et al.*, 2016; Abudabos *et al.*, 2017). Research has shown that *M oleifera* is a promising natural herb that could enhance the production performance and health status of birds as an alternative to antibiotics and growth promoters.

Moringa oleifera Lam. (Moringaceae family) popularly referred to as the ‘‘Miracle tree”, is widely cultivated across the world due to its multiple uses and adaptability. The plant has a high nutritive and pharmacological value, while its leaves are a rich source of minerals, vitamins and many health beneficial secondary metabolites with a significant anti-diabetic potential (Zainab *et al*. 2020). The positive effects of dietary *M. oleifera* supplementation on animal performance have been observed in broilers and laying hens (Lu *et al*., 2016). This study was carried out to assess the influence of moringa leaf meal feed as an additive on carcass characteristics and hematological parameters of broilers.

MATERIALS AND METHODS

The experiment was carried out in an open mesh sided, deep litter poultry house of the Department of Agricultural Technology Kaduna Polytechnic, Kaduna. The house was cleaned, washed and disinfected using formalin. Each pen floor was covered with enough wood shavings with allocation of one tubular feed + trough and one round fountain drinker. Two hundred and forty unsexed day-old Zam strain broiler chicks were purchased from a local hatchery and randomly allotted into 16 pens (four groups) of 15 chicks in a pen, in a completely randomized design. The chickens were allocated to four diets which were formulated with various levels of supplemental *M. oleifera* leaf meal (250 g, 500 g and 750 g *M. oleifera* inclusion per 100 kg diet as treatments 2, 3, and 4, respectively) in addition to a control diet (treatment 1) without *M. oleifera*.

Fresh matured *M. oleifera* plants was sourced from a local market within Kaduna metropolis. The leaves of the plant were removed from the stems, sorted, cleaned with tap water, and dried under shade for 1-2 days. Four diets were formulated for both the starter and finisher phases. The experimental diets were made iso-caloric and iso-nitrogenous and formulated to meet the National Research Council, (NRC, 1994) requirements of broiler chicks. The diets were also formulated to meet the crude protein requirements of starter and finisher diets (20% and 18.79 %, respectively), as presented in table 1. Both diets had a metabolizable energy of 3,200 kcal/kg and 3,100 kcal/kg, respectively and supplemented with required vitamins, minerals and amino acids.

Table 1. Composition and nutrient content of broiler starter and finisher diets (air-dry basis, %)

Ingredient	Starter ration (%DM)	Finisher ration (%DM)
Maize	53.45	63.40
Soya bean cake	27.50	17.40
Groundnut cake	10.00	10.00
SOS	5.00	5.00
Limestone	0.50	0.50
Born meal	2.80	2.80
Common Salt	0.23	0.23
Vitamin-mineral Premix*	0.24	0.24
Methionine	0.20	0.20
Lysine	0.05	0.20
Enzyme	0.03	0.03
Mobilizing energy (Kcal/kg)	2.894.00	2,978.07

DM- Dry Matter * Biomix premix supplied per kg of diet

Two hundred- and forty-day old Zam strain broiler chicks of mixed sexes were sourced from commercial private poultry farm and used for the experiment. Sixty chicks were housed for each of the four dietary treatments (with graded levels of *M oleifera* leaf meal) compared, with three pens per treatment as replicates and fifteen birds in each replicate using completely randomized design. Each pen was provided with an aluminum flooding pan feeder (300 mm) and mini plastic drinkers of the same size (300mm). The broiler chicks used for the study were raised in deep litter and brooded for the first one week in an electrically heated battery brooder cage. Routine management, vaccination and medication were carried out as and at when due, and all the possible steps were taken to avoid animal suffering at each stage of the experiment.

The chicks in groups and feeds were weighed weekly according to cage numbers using a normal scale. Gain in body weight (GBW), feed consumption (FC), average daily gain (ADG) and feed conversion efficiency (FCE) of the chicks were recorded at the beginning of each week, starting from placement until slaughter. At the end of experimental period, all the birds were slaughtered and the trachea, esophagus, crop, intestinal tract, giblet (heart and gizzard), spleen, kidney, oil glands and reproduction organs were removed. Then the carcass and liver were weighed. In addition, blood samples were collected and taken to pathology laboratory for hematological indices determination.

Furthermore, the chemical components of *M oleifera* leaf meal (dry matter, crude protein, phosphorus, crude fiber, ME, ash and nitrogen free extract) were determined according to AOAC (2000) and results presented in table 2.

All the data collected were analyzed statistically using one-way analysis of variance according to Steel and Torie (1981) and means were compared using Duncan's multiple-range test. Statistical significance was determined at $P < 0.05$. The analysis was carried out using statistical analysis system (SAS, 2005) program.

Table 2: Nutrient Composition of *Moringa oleifera* leaf meal (dry matter basis)

Parameter	Composition (%)
Dry matter	82.80
Crude protein	27.60
Crude fibre	16.7
Phosphorus	0.80
Ash	3..30
Moisture	7.31

RESULTS AND DISCUSSION

Carcass characteristics

The result of the influence of *M. oleifera* leaf meal feed inclusion on performance of broilers with respect to carcass characteristics is presented in Table 3. The result showed that percentages of heart and liver in relation to chicken live body weight did not differ significantly between the treatment groups at the end of the experimental period. Although no significant variation was observed in percentages of heart and liver, the potential benefits of dietary MOL inclusion on animal production have been previously reported, such as improving productive performance in broilers and laying hens (Melesse *et al*., 2013), improving carcass quality and meat quality in broilers (Nkukwana *et al*., 2014).

In addition, the data further revealed that statistically significant differences (p<0.05) existed between treatments with respect to the live body weight, carcass yield and gizzard. Abdel Wahab *et al*. (2020) had reported that birds fed MOSP at 0.75% with enzyme had significantly higher body weight (BW) than control with enzyme and other dietary treatments. Similarly, all levels of germinated *M. oleifera* seed (GMOS) was reported to significantly increased BW and BWG at 42 days of age compared to the control group (Mouse *et al*., 2016).

The chickens fed with 500g *M. oleifera* inclusion per kg broiler feed were observed to have the highest mean live weight and carcass yield of 3,044.22 g and 2,448.00 g, respectively that ware statistically comparable to the control treatment but significantly higher than all moringa supplemented diet treatment groups in the experiment. Results obtained herein are in line with Ochi *et al*. (2015) who indicated that the use of *M. oleifera* seed powder (MOSP) at levels of 0.5, 1, and 2% in the diet of the broilers, significantly enhanced ($P < 0.05$) their body weight, weight gain and feed consumption.

With regard to gizzard, the result indicated that an increase in the level of *M. oleifera* leaf meal feed inclusion from 250 g to 500 g had no significant effect on the gizzard, while additional increase in the supplement to 750 g had significant effect on the parameter. The highest percentage value of the gizzard (3.40%) was recorded in the diet of 750g which was significantly (p<0.05) lower than the least (2.30%) obtained in the control treated birds. There was no significant variation in percentage values of the heart and liver in relation to live body. With regards to the carcass indices, it has been reported that dietary manipulation is an important way to improve the meat quality in poultry (Cheng *et al*., 2019). Therefore, Mahfuz *et al*. (2020) has reported that dietary supplementation of antioxidant-enriched moringa leaves would be a potential strategy to improve the meat quality in broilers.

Table 3. Carcass characteristics of broilers fed moringa leaf meal

Parameters (% Live weight)	Different Levels of moringa leaf meal supplement in broiler diet				P-Values	
	0	250	500	750	Sign.	SEM
Live weight (g)	3,010.00$_a$	2,766.56$_b$	3,044.22$_a$	2,782.44$_b$	*	48.44
Heart	0.32	0.45	0.47	0.39	NS	0.6255
Liver	1.67	1.72	1.78	1.85	NS	0.0735
Gizzard	2.30$_c$	2.99$_{ab}$	2.84$_b$	3.40$_a$	*	0.16
Carcass Yield (g)	2,233.30$_{ab}$	1,900.11$_c$	2,448.00$_a$	2,300.00$_b$	*	88.52

Means in the same row bearing different subscripts are significantly different (P<0.05): * = significant (P = 0.05); NS = Non-significant; SEM = Standard Error of Mean

Hematological parameters

The data indicated that except for the packed cell volume (PVC) and white blood cells (WBC) there was no statistically significant response observed in all hematological indices of the broilers due to the application of all the treatments. It is on record that, the hematological parameters of the blood provide information on poultry health and nutritional deficiency, as well as physiological changes in the growth of broilers. Abdel Wahab et al. (2020) observed higher WBC count in birds that received 1% MOSP without enzyme and those of the control diets compared with the other dietary treatments. Previously, Maxwell and Robertson, (1998) reported an increase in the number of heterophils in broilers during mildly or moderately stressful conditions and concluded that the heterophil/lymphocyte ratio in the blood can be used to detect the presence of physiological stress in poultry birds. This study also observed that an increase in the level of *M. oleifera* leaf meal from 0 to 500 g per 100 kg of feed did not significantly increase the PVC and WBC while further increase in level of *M. oleifera* leaf resulted in a significant decline in the PVC and non-significant reduction in WBC as indicated in table 4. In line with this study, Ebenebe *et al*. (2012) examined the roles of *M. oleifera* leaf meal at 10% and 15% level on the hematological parameters in broilers and reported that feeding Moringa leaf meal in broilers resulted in increased red blood cell (RBC), PCV, and hemoglobin (HB) values in both levels of diets. Finally, it was stated that *M. oleifera* leaf meal may be used up to 10% level in broiler diets.

With respect to relationship between moringa plant and blood constituents of broiler it was hypothesized that higher amounts of natural fiber in moringa leaves may have a role in lowering cholesterol level by increasing lipid metabolism in the host body (Mahfuz, 2020). In addition, a study conducted by Alnidawi *et al*. (2016) showed that blood parameters, like hemoglobin percent, total red blood cells number, and total packed cell volume, were found to be higher at 20% supplementation levels of *M. oleifera* than the control diet.

Table 4. Hematological parameters of broilers fed moringa leaf meal

Parameters (%)	Reference Values	**Different levels of** moringa leaf **supplement in broiler diet**				**P-Values**	
		0	250	500	750	Sign.	SEM
PCV	25-45[1]	37.63_a	36.62_a	36.51_a	32.15_b	*	1.15
RBC ($x10^{12}$/L)	2-4[1]	2.58	2.51	2.64	2.20	NS	0.09
Hb conc.	7-13[1]	11.80	11.62	11.46	1008	NS	0.37
WBC ($x10^9$/dL)	9-31[1]	92.51_{ab}	106.53_a	98.01_{ab}	82.73_b	*	5.46
Heterophils (unit)	40-48[3]	1.92	3.11	3.32	3.56	NS	1.01
Lymphocytes (unit)	24-84[2]	60.44	57.19	88.54	87.56	NS	22.47

Means in the same row bearing different subscripts are significantly different (P<0.05): * = significant (P = 0.05); NS = Non-significant; SEM = Standard Error of Mean; PCV = Packed Cell Volume; RBC = Red Blood Cells; HB = Hemoglobin Concentration; WBC = White Blood Cells

CONCLUSION

In conclusion, dietary moringa leaf meal inclusion as a feed additive may have significant influence on the performance of broilers in respects of the carcass characteristics and hematological parameters. These results suggested that MOL could be used as a feed ingredient for broilers to improve the carcass quality and blood hematological indices with little or no adverse effects on growth performance.

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ASSESSMENT OF MACRO NUTRIENT CONTENT OF SOME SELECTED AGRO FORESTRY TREE SPECIES AND SOIL COMPOSITION STATUS IN ADJACENT AGRICULTURAL FARM

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ABSTRACT

This study assessed macro nutrient content in some selected agro forestry tree species and soil composition status in adjoining agricultural farm. The research was conducted at forest Arboretum of the Department of Forestry and Wildlife Management Federal University Dutsinma, Katsina State Nigeria. Plant materials were collected from five randomly sampled trees; Faidherbia albida, Leuceana leucocephela, Senna siamen, Gliricidia sepium, Albizia lebbeck. A plot of 50×50 m was measured and the trees were counted. Five trees were randomly selected from each selected tree species out of which the leaves were collected. In each of the collected samples was pooled /bulked together while composite samples were also taken. The leafy biomass was air- dried and the sample was grounded and passed through a sieve of 2 mm size. Then, 2.0 g of each sample of the selected species was put into a digestion flask which was washed with distilled water.10 ml of 4 % perchloric acid ($HCLO_4$) was added to the samples under a fume cupboard. The contents was mixed and heated strongly on digestion block under the $HCLO_4$ fume cupboard. The contents were allowed to cool and then 50 ml of distilled water will then be added. The solution was transferred into a 100 ml Pyrex volumetric flask. The soil physical and chemical properties showed that arboretum had 780 g/kg sand, 100 g/kg silt and 120 g/kg clay while chemical properties also showed as folows pH of 6.20, organic carbon 7.00g/kg. It was found that Faidherbia albida, Leuceana leucocephala, Gliricidia sepium and Albizia lebbeck had significantly higher values (0.100.002a, 0.100.001a, 0.100.001a and 0.100.001a) in magnesium. The study concludes that Gliricidia sepium and Albizia lebbeck contained the higher mean concentration of macro nutrients in nitrogen, phosphorus, magnesium and sodium respectively. The study recommends that Gliricidia sepium, Albizia lebbeck and Faidherbia albidashould be considered while selecting species for augmenting soil potential and improving soil fertility for various agroforestry activities.
Keywords: *Macronutrient, Agroforestry tree, Species, Soil Composition Status and Agricultural Farm*

INTRODUCTION

The perceived rise in global food demand has led to a desire for organic food (Ezeorji *et al*., 2020). Future livelihoods of smallholder farmers around the world, particularly in the tropics, face a major threat from environmental degradation brought on by rising food production demands and related changes in land usage (Kang and Akinnifesi 2000). Due to a combination of high rates of erosion, nutrient leaching, crop residue clearance, and ongoing cultivation of the soil without sufficient fertilization or fallow periods, studies show that soil fertility is rapidly declining (Mugwe *et al*. 2007). Although significant efforts have been made to make inorganic fertilizers cheap for farmers, such as fertilizer price subsidies, resource-poor farmers still are unable to fulfill crop fertilizer requirements and struggle to achieve and sustain high productivity in intensively planted fields (Partey, 2011).

Chemical fertilizer has detrimental impacts on the soil and plants in addition to synthetic and chemical fertilizer, pesticides that have been used for years to improve global food supply (Mondal *et al*., 2015). Composting is the ultimate form of trash recycling since it produces fertilizer from a variety of organic materials that have decomposed. It is made up of generally stable decomposed organic compounds that are the outcome of rapid biological breakdown of organic materials under controlled aerobic conditions. For agricultural production, it is created from leftover plants and animals (Adugna, 2016). Vermicompost fertilizer has been made using a variety of organic waste products, including rice straw, dry grass, chippings, cow manure, dried leaves, rotten watermelon,

papaya, pine apples, custard apples, and guavas (Mondal *et al*., 2015; Devi and Prakash, 2015). Both conventional compost and vermicompost fertilizer are excellent sources of micro- and macro-mineral nutrients that, when added to the soil, improve soil nutrients and organic matter (Hernandez *et al*., 2010, and MongJam *et al*., 2019). Based on how much a plant needs to thrive, soil nutrients are classified as either micro or macro nutrients (Akenga *et al*. 2014). According to their requirements and the relative necessity for fertilization, the fourteen mineral nutrients are categorized as either micro or macro nutrients (Sneha *et al.*, 2018).
However, soil chemistry and physical conditions can also have an impact on how quickly litter decomposes. Decomposition is primarily fueled by microbial activities and can be best anticipated by environmental parameters like temperature and precipitation as well as litter quality (Liu, *et al*., 2006). Quantitative characterization of nutrient cycling in terrestrial ecosystems depends critically on the study of the variables influencing litter decomposition. This section discusses the key influences on the decomposition process, including plant litter properties, soil qualities, and environmental factors.
In recent years, increasing soil fertility through fertilizer application has been the norm. However, because chemical fertilizers are either uncommon or expensive in Nigeria, many farmers cannot afford to buy them, and those who might do so do not have access to them when they are needed. The use of agroforestry tree species, which have the ability to fix nutrients and ease the issues associated with soil fertility decline, is a sustainable method of addressing the problems of soil fertility reduction. As a result, nitrogen-fixing agroforestry plants could be employed to supplement soil improvement for increased crop yield. In terms of nutrient release and decomposition, chemical compositions of the leafy biomass that are influenced by biological and environmental factors (such as decomposers, litter quality, temperature, and moisture, etc.) are another crucial area of concern. The term "macro nutrients" refers to those nutrients that plants need in relatively high concentrations. Examples of macro nutrients include nitrogen (N), phosphorus (P), potassium (K), calcium (C), magnesium (Mg), and sodium (Na). A certain amount of moisture is necessary for the release of these nutrients. According to studies Ajayi *et al*. (2007); Sanchez (2002), leguminous tree leaf litter mulching in agroforestry plots increases crop productivity. However, these macronutrient concentrations differ from one species to another depending on the organism. The concentration of macro-nutrients in a few chosen, widely used agroforestry tree species and the nutrient status of the adjacent farm area must thus be evaluated.

METHODOLOGY

The research was conducted at forest Arboretum of the Department of Forestry and Wildlife Management Federal University Dutsinma, Katsina State Nigeria. The area lies between (Latitude 8^0 29 N, Longitude 4^0 35 E and 307 meter (above sea level), during the 2018 dry seasons. Dutsin-ma is characterized by an annual rainfall of 1,186 mm while the mean annual temperature and relative humidity are 29^0 and 85 % respectively. The soil is well drained, and the order is Alfisols belonging to the Tanke series (23).The underlying geologist is made of sand stone ranging from fine to coarse grained light brown colour. The dominant soil types include; sand, silt, clay and textural class (Lukman, 2018).
Plant materials were collected *from Faidherbia albida, Leuceana leucocephela, Senna siamen, Gliricidia sepium, Albizia lebbeck*. A plot of 50 m by 50 m was measured and the trees were counted. Five trees were randomly selected from each selected tree species out of which the leaves were collected. In each of the collected samples was pooled /bulked together while composite samples was also taken. The leafy biomass was air- dried and the sample was grounded and passed through a sieve of 2 mm size. Then, 2.0 g of each sample of the selected species was put into a digestion flask which was washed with distilled water.10 ml of 4 % perchloric acid ($HCLO_4$) was added to the samples under a fume cupboard. The contents was mixed and heated strongly on digestion block under the $HCLO_4$ fume cupboard. The contents were allowed to cool and then 50 ml of distilled water will then be added. The solution was transferred into a 100 ml Pyrex volumetric flask.
The volume was made up to mark with distilled water. Then the solution was stored in plastic bottles and labelled for analysis. The digested sample solutions of the plants was subjected to laboratory analysis to determine the Total Nitrogen (N), Potassium (K), Calcium (Ca), Magnesium (Mg), and Sodium (Na). Total Nitrogen was determined by Macro-Kjeldahl method as described by Jackson (1985) Phosphorus was detemined by Vanadomolybdo Phosphoric yellow colour as described by Kitson and Milton (1994).
The air-dried sample was taken to laboratory for physico chemical analysis. The grounded samples that was analysed include: organic carbon content which was determined by wet oxidation method of Walkley-Black as described by Allison (1965). Total Nitrogen was analysed by Macro-Kjeldahl digestion, followed by distillation and titration (Brandstreet, 1965; Anderson and Ingram, 1993). The C: N ratio was computed as ratio of N to C. Available P was extracted by Bray method. The P concentration in the extract was determined calorimetrically by using the Spectronic 20 and absorption was read-off as described by Bray and Kurtz (1945) and modified by Murphy and Riley (1962). Exchangeable base, Na, K, Ca and Mg were extracted using ammonium acetate. K was determined on flame photometer and Ca and Mg by Atomic Absorption. Soil sample was randomly collected from five locations at the depth of (0-30 cm) both from Arboretum and adjoining agricultural farm for physical and chemical analysis which include: Sand, silt, clay and, textural class, pH, organic carbon, total nitrogen and available phosphorus, using standard methods. Total nitrogen was analyzed by Macro-Kjeldahi digestion,

followed by distillation and titration (Brandstreet, 1965; Anderson and Ingram, 1993). Ammonium was determined by the salicylate-hypochlorite colorimetric method (Anderson and Ingram, 1993) whereas NO_3^- plus nitrate (NO_2) was determined by cadmium reduction method (Dorich and Nelson, 1984).

Data analysis

One-way analysis of variance was employed to test for the significant differences in the micronutrients and physico-chemical composition of the soil. Significant means were separated using the Fishers Least Significant Difference (LSD) at P=0.05

RESULTS

The results of the physico-chemical properties and exchangeable bases (cations) of the soils type on arboretum and adjacent agricultural farm soils are presented in table 1 below. The soil physical and chemical properties revealed that arboretum had 780 g/kg sand, 100 g/kg silt and 120 g/kg clay. The chemical properties also showed that pH of the soil was 6.20, organic carbon 7.00g/kg, total nitrogen 0.42 g/kg, carbon to nitrogen ratio 16:67 and available phosphorus 3.10g/kg respectively. Soil exchangeable bases/cations were observed to have 2.70 mg/kg, calcium, 0.50 mg/kg, magnesium, 0.31 mg/kg, potassium and 0.12 mg/kg sodium. Furthermore, it was also observed that adjacent agricultural farm soil physical and chemical properties had 820 g/kg sand, 80 g/kg silt and 120 g/kg clay while chemical properties also showed that pH was 6.10, organic carbon (5.00 g/kg), total nitrogen (0.28 k/kg), carbon to nitrogen ratio (17:86) and available phosphorus (2.20 g/kg) respectively. Soil exchangeable bases/cations showed 2.12 mg/kg of calcium, 0.61 mg/kg of magnesium, 0.34 mg/kg of potassium and 0.11 m/kg of sodium respectively

Table 1: Physico-chemical properties and exchangeable bases of the soils

Soils type	Physical properties(g/kg)				Chemical properties					Exchangeable bases (mg/kg)			
	Sand	Silt	Clay	Textural class	pH	OC (g/kg)	TN	C:N	AP (mg/kg)	Ca	Mg	K	Na
Arboretum	780	100	120	Loamy sand	6.20	7.00	0.42	16:67	3.10	2.70	0.50	0.31	0.12
Adjacent agricultural farm	820	80	100	Loamy sand	6.10	5.00	0.28	17:86	2.20	2.12	0.61	0.34	0.11

N:C: Nitrogen carbon ratio; **K:** Potassium; **Ca:** Calcium; **Mg:** Magnesium; **Na:** Sodium, OC Organic carbon, TN=Total nitrogen, Av = Available phosporus

Table 2 shows the chemical composition of the selected leafy biomass of agroforestry tree species. The result shows that the highest nitrogen content (4.10) was found in *Gliricidia sepium*, while the least (3.20) was found in *Leuceana*. However *Fadheibia* gave the highest concentration of carbon (77.43) followed by AL and the least (48.04) was found in GS. Carbon to Nitrogen ration was highest (21.51) in FA and lowest GS (11.72)

Table 2 shows the chemical composition/concentration of the selected leafy biomass of agroforestry tree species the result revealed that *Faidherbia albida* have significantly higher values (77.43, 21.51 and 14.81) in carbon, C:N ratio and PP:N ratio, while Leuceana *leucocephala* also had significantly higher value (20.00a) in cellulose than other selected leafy biomass. However, Senna siamen was noticed to have significantly higher value (0.41a) in polyphenol, whereas Gliricidia sepium had (4.10a) in nitrogen than in other selected leafy biomass. Albizia lebbeck was discovered to have significantly higher values (15.59a, 54.29a, 4.15a and 4.22a) in lignin, lignin to polyphenol ratio, lignin to nitrogen ratio and lignin plus polyphone to nitrogen ratio respectively than in other selected agroforestry tree species leafy biomass (Table 2).

Table 2: Mean chemical composition/concentration of the selected leafy biomass of agroforestry tree species

Species	N	C	C:N	L	PP	L:PP	L:N	PP:N	(L+PP):N	Cellulose
FA	3.60b	77.43a	21.51a	5.41e	0.24c	22.26d	1.50e	14.81a	1.50e	12.16c
LL	3.20c	50.73d	15.86d	12.26b	0.37b	38.19b	3.83b	9.97d	3.93b	20.00a
SS	3.60b	58.75c	16.32c	6.33d	0.41a	15.14c	1.76d	8.61e	1.87d	12.16c
GS	4.10a	48.04e	11.72e	11.11c	0.32c	29.71c	2.71c	10.96c	2.80c	6.17d
AL	3.75b	74.76b	19.94b	15.58a	0.24d	54.29a	4.15a	13.07b	4.22a	17.33b

FA: *Faidherbia albida;* **LL:** *Leuceana leucocephela;* **SS:** *Senna siamen;* **GS:** *Gliricidia sepium;* **AL:** *Albizia lebbeck;* **N:** Nitrogen; **C:** Carbon; **C:N:** Carbon to nitrogen ratio; **L:** Lignin; **PP:** Polyphenol; **L:PP:** Lignin to polyphenol ratio; **L:N:** Lignin to nitrogen ratio; **PP:N:** Polyphenol to nitrogen ratio; **(L+PP):N:** Lignin plus polyphenol ratio nitrogen

Mean concentration of macro nutrient in the selected leafy biomass of agroforestry tree species was presented in table 3 below. The result shows that the nitrogen content of *Gliricidia sepium* (4.1%) was significantly higher than all the other species, while there were no significant difference in the nitrogen content of FA, SS and AL (3.60%.3.20% and3.75%).

The table revealed that *Faidherbia albida, Leuceana leucocephala, Gliricidia sepium* and *Albizia lebbeck* had same significant higher values (0.10%, 0.10%, 0.10% and 0.10%) in magnesium while *Senna siamen* had significantly lower values (0.070.012%) in magnesium than in other selected leafy biomass. *Gliricidia sepium* also had significantly higher values (4.100.012%, 460.100.058ppm, 1.500.115%) in nitrogen, phosphorus and sodium respectively; meanwhile, *Leuceania leucocephala* and *Albizia lebbeck* had significantly higher values (0.230.011% and 1.340.017%) in calcium and potassium than other selected leafy biomass

Table 3: Mean concentration of macro nutrient in the selected leafy biomass of agroforestry tree species

Species	N %	P ppm	K %	Ca %	Mg %	Na %
FA	3.60±0.115b	353.07±1.33e	1.02±0.015b	0.14±0.001bc	0.10±0.002a	0.07±0.029c
LL	3.20±0.115c	380.70±0.115c	0.75±0.018c	0.23±0.011a	0.10±0.001a	0.56±0.012b
SS	3.60±0.058b	420.62±0.123c	0.84±0.023c	0.20±0.058b	0.07±0.012b	0.08±0.006b
GS	4.10±0.012a	460.10±0.058a	0.20±0.058d	0.11±0.001c	0.10±0.001a	1.50±0.115a
AL	3.75±0.115b	370.20±0.058d	1.34±0.017a	0.12±0.001c	0.10±0.001a	0.62±0.012b

FA: Faidherbia albida; **LL:** Leucaena leucocephala; **SS:** Senna siamen; **GS:** Gliricidia sepium; **AL:** Albizia lebbeck; **N:** Nitrogen; **P:** Phosphorus; **K:** Potassium; **Ca:** Calcium; **Mg:** Magnesium; **Na:** Sodium

Figure 1 below shows that *Gliricidia sepium* had significantly higher nitrogen value (4.10%) followed by *Albizia lebbeck* (3.75%) and the least was observed in *Leucaena leucocephala* (3.20%). Furthermore, *Albizia lebbeck* was significantly higher (1.34%) in potassium, followed by *Faidherbia albida* (1.02%) and the least was noticed in Senna siamen (0.84%). Meanwhile, *Gliricidia sepium* had higher significantly value (1.50%) in sodium followed by *Albizia lebbeck* (0.62%) and *Leucaena leucocephala* was observed with least value (0.56%).

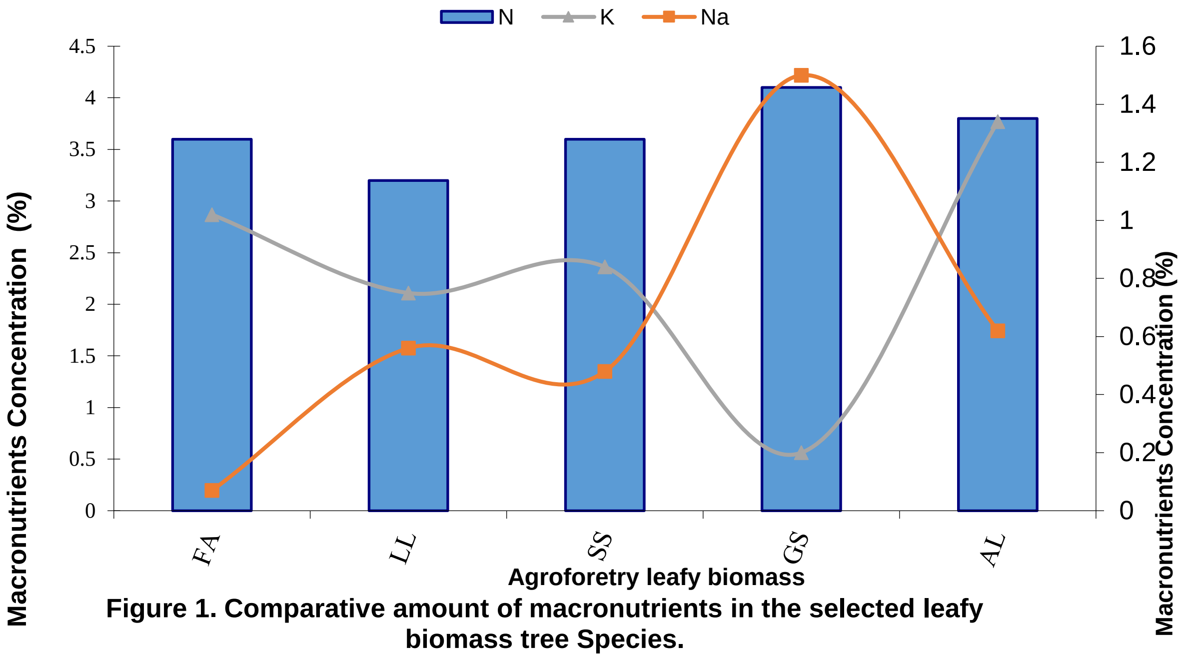

Figure 1. Comparative amount of macronutrients in the selected leafy biomass tree Species.

FA: *Faidherbia albida;* ***LL:*** *Leuceana leucocephala;* ***SS:*** *Senna siamen;* ***GS;*** *Gliricidia sepium; AL: Albizia lebbeck*
Figure 2 below revealed that *Gliricidia sepium* had higher significantly value (460.10%) in phosphorus, followed by *Senna siamen* (420.60%) and *Leucaena leucocephala* had the least value (380.70%). Furthermore, *Gliricidia sepium* had significantly higher value (0.10%) in calcium, followed by *Leucaena leucocephala* (0.10%) and *Faidherbia albida* with least value (0.09%). Meanwhile, *Gliricidia sepium* had significantly higher value (1.5%) in magnesium, followed by *Albizia lebbeck* with value (0.62%) in magnesium and the least value was observed in *Leucaena leucocephala* (0.55%).

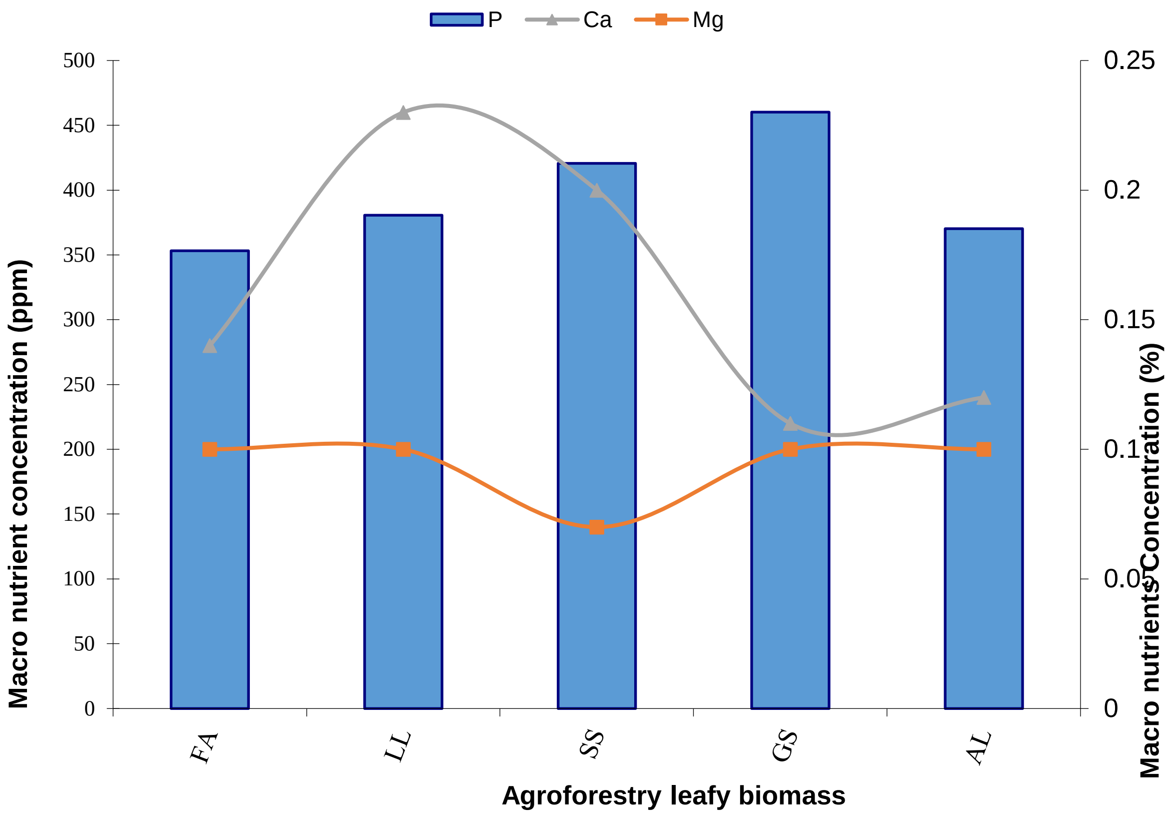

Figure 2. Comparison of amount of macronutrients in the selected leafy biomass tree species

FA: *Faidherbia albida;* ***LL:*** *Leuceana leucocephala;* ***SS:*** *Senna siamen;* ***GS;*** *Gliricidia sepium; AL: Albizia lebbeck.*

DISCUSSION OF FINDINGS

The results of the study revealed that nitrogen and organic carbon in Arboretum soil was slightly higher than that of adjacent agricultural farm. These soil chemical properties in the Arboretum soil actually indicates the quality of the soil, owing to the influence of nutrient contents resident in it as a result of biomass and litter that has decomposed and in turn added nutrients to the soil as fertility improvement. This is in line with Oyebamiji *et al.* (2017) who stated that, biomass decomposition increase the nutrient content of the soil per period of time. Similarly, Smithson and Giller (2002) reported that the higher nutrients composition of the Arboretum can be due to reduced leaching at the arboretum floor due to canopy cover and thereby preventing direct run-off of water in form of erosion. It has been documented that agroforestry remain one of the important and efficient means by which nutrients leaching can be reduced (Odiwe *et al.*, 2016). This leafy biomass optimally functioned as nutrient fixer and agents of leaching control because they were allowed to decompose without being fed on by animals. The University arboretum is a restricted area for research, and this has led it to have minimum entrance and zero encroachment. The soil types of arboretum and adjacent agricultural farm land belong to loamy sand textural class; so also, the soils exhibit weak acidity respectively. However, the disparity in the nutrients composition of the two (2) study areas might be due to differences in the micro climatic and edaphic structures of each of the places and this is in line with Makaza and Shoko (2013). The chemical composition or concentration of the selected leafy biomass showed that *Gliricidia sepium* among other biomass will decompose faster and will release mineral nutrients due to its high nitrogen content and low carbon to nitrogen ratio contents. The better performance of *Gliricidia sepium* in terms of nutrients release agrees with Oyebamiji *et al.*, (2017).The rate of nutrients release by the leafy biomass differs from one species to the other. Similar result of this was reported from other agroforestry leafy biomass in Indonesia (Matheus *et al.,* 2013).

Although, the results of the nutrients composition analysis of the leafy biomass were found to be significantly different from one another, it has however been established that *Gliricidia sepium*, *Leuceana leucocephala* and *Senna siamen* are excellent Nitrogen fixer (Budelman, 1989). The polyphonol content of the leafy biomass are generally low and still significantly different though, this might cause a faster release of the nitrogen content of the leafy biomass. Decomposition and quick nitrogen release have been found to be enhanced by lignin and polyphenol (Makaza and shako, 2013). Furthermore, the value of the macro nutrient in Nitrogen for *Albizia lebbeck* in the present study is below the macro nutrient of nitrogen in *Albizia lebbeck* (5.60) obtained elsewhere Bichi, (2012). Similarly, both phosphorus (370.2 ppm) and potasium (1.34 %) of the present study were lower than those obtained in Bichi (2012). This disparity in the macro nutrient content is an indication of different nutrient content influenced by variation in locations. However, it is noteworthy that all the biomass species have significant amount of the macro nutrients required in agroforestry system

CONCLUSION

This study conclude that *Gliricidia sepium* and *Albizia lebbeck*contained higher concentration of macro nutrients; nitrogen, phosphorus, magnesium and sodium, which are pertinent in plant development. Arboretum has better soil physical, chemical and exchangeable bases composition than adjacent agricultural farm. The soil is neutral while the textural class is loamy sand an indication of its suitability for agroforestry purpose *Albizia lebbeck and Faidherbia albida*were found to be superior in terms of the chemical decomposition, while *Gliricidia sepium* was higher in nitrogen release among all the selected leafy biomass.

RECOMMENDATIONS

Due to high fertility and chemical content in the Arboretum soil, it is therefore advisable that it should be used for agroforestry activities leafy biomass in forms of alley cropping. Moreover, *Gliricidia sepium, Albizia lebbeck* and *Faidherbia albida*should be employed or considered while selecting species for soil fertility improvement. Agroforestry trees that are rich in nitrogen and other macro nutrient capacity should be used as alternative to inorganic fertilizer that are relatively scarce, costly and adversely affecting soil improvement.

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EVALUATION OF SOIL COMPOSITION AT ABADOLE ARBORETUM AND ADJACENT AGRICULTURAL FARMS, FEDERAL UNIVERSITY DUTSINMA, KATSINA STATE NIGERIA

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ABSTRACT
This research was conducted with the view of assessing Soil Composition of Abadole Arboretum and Adjacent Agricultural Farms at Federal University Dutsinma. Plant materials were collected from; Faidherbia albida, Leuceana leucocephela, Senna siamen, Gliricidia sepium, Albizia lebbeck. A plot of 50x50 m was measured and trees were counted. Total Nitrogen was analysed by Macro-Kjeldahl digestion, followed by distillation and titration. Soil samples were randomly collected from five locations at the depth of (0-30 cm) from Arboretum and adjacent agricultural farm for physical and chemical analysis which include:Sand, silt, clay and, textural class, pH, organic carbon, total nitrogen and available phosphorus respectively. Prior to the commencement of the experiment using standard methods. Total nitrogen was analyzed by Macro-Kjeldahi digestion, followed by distillation and titration. The result of this research revealed that,Gliricidia sepium and Albizia lebbeck contained the higher mean concentration of macro-nutrients, nitrogen, phosphorus, magnesium and sodium which are pertinent in plant development. Arboretum has better soil physical, chemical and exchangeable bases composition than adjacent agricultural farm. The soil types were also noted to be nearer neutral, meaning that, contain weak acidity and loamy sand in nature.Furthermore, Albizia lebbeck and Faidherbia albida were found to be superior in terms of the chemical decomposition, while Gliricidia sepium was higher in nitrogen release among all the selected leafy biomass. As a result of high fertility and chemical content in the Arboretum soil, it is therefore advisable that it should be used for agroforestry activities leafy biomass in forms of alley cropping. Moreover, Gliricidia sepium, Albizia lebbeck and Faidherbia albida should be employed or considered while selecting species for augmenting soil potential and/ or improving soil fertility for various agroforestry activities

INTRODUCTION
Decomposition of leaf litter is an important source of nutrients in forest ecosystems and farming systems. In most forests and farming systems in the tropics the major source of nutrients for trees and food crops is from the decomposition of plant material. Decomposition refers to the process that converts fresh and dead organic matter into smaller and simpler compounds. Decomposition is mainly a biological process carried out by insects, worms, bacteria, and fungi both on the soil surface and in the soil. The products of complete decomposition include carbon dioxide, water, and Inorganic ions (e.g. ammonium, nitrate, phosphate, and sulphate). The fresh and dead organic matter, which is referred to as mulch, is broken down by microbial decomposers and insects. Organically bound nutrients are then released as free ions to the soil solution which are then available for uptake by plants. Vegetative materials that are used as mulching material include grass, crop residues and leaves from pruning of trees. It is mainly a practice in which organic materials are placed on the surface or incorporated in the soil to maintain and improve soil fertility (Food and Agriculture Organization, 1975).
The rate of decomposition of mulch is influenced by many interacting factors which include the composition of bacteria, fungi, invertebrates, temperature, soil moisture and quality of the mulch as a food source for the decomposers. For soil moisture, decomposition of mulch is inhibited in very dry soils because bacteria and fungi dry out. Decomposition of mulch is also slow in very wet soils because anaerobic conditions develop in saturated soils.

Anaerobic decomposition of mulch is less efficient than aerobic and as a result is slower. Thus, decomposition of mulch proceeds fastest at intermediate water contents

Litter decomposition plays a crucial role in the budget of forest ecosystem where vegetation depends mainly on the recycling of nutrient contained in the plant detritus. During the process, litter fall and decomposition is influenced by environmental factors and also by physical and chemical properties of plant parts such as stem wood, leaves, root etc. (Temel, 2003; Oyebamiji *et al.,* 2017). Litter fall is a fundamental process in the nutrient cycling and it is the main means of transfer of organic matter and mineral element from vegetation to the soil surface (Reginal *et al.,* 1999). Litter fall has also been described as a major pathway for the return of organic matter and nutrients from aerial parts of the plant community to the soil surface. Decomposition is a key process in the nutrient cycling and formation of soil organic matter (Berg and McClaugherty, 2002). The decomposition of leaf litters is a major source of nutrient in forest ecosystem (Temel, 2003).

Agroforestry is the production of trees and of non-tree crops or animals on the same piece of land and provide diverse output from the same land units. These land use types were conserving different types of plant species diversity in pieces of land and minimizes the impacts of community in the natural forest. Agroforestry systems make maximum use of the land. Every part of the land is considered suitable for useful plants. Emphasis is placed on perennial, multiple purpose crops that are planted once and yield benefits over a long period of time. Such benefits include; construction materials, food for humans and animals, fuels, fibers, and shade. Trees in agroforestry systems also have important uses such as holding the soil against erosion and improving soil fertility. Soil nutrient declining is considered to be a major threat to food security and natural resource conservation in Sub-Saharan Africa (SSA). According to Bationo *et al*. (2006), Africa loses US$4 billion per year due to soil nutrient declining. The problem is pervasive among mixed crop and livestock farming systems of the region, especially Nigeria where competing uses for crop residues such as livestock fodder or household fuel mean that nutrients are not sufficiently replenished into the soil. Nutrient replacement using mineral fertilizers is a limited option for many smallholder farming households of Nigeria. It is observed that, region with lowest mineral fertilizer application rates will experience, much lower crop yields than those using organic fertilizer (Morris *et al.,* 2007). In Southern Africa, the consequent downward spiral of soil fertility has contributed to a corresponding decline in crop yields, an increase in food insecurity, food aid and environmental degradation (Mafongoya *etal.*, 2006).

Decomposition is primarily driven by microbial activities and can be best predicted by environmental factors such as temperature and precipitation, as well as litter quality, but soil chemistry and physical conditions can also influence the rate of litter decomposition (Liu, *et al*., 2006). Study of the factors that affect litter decomposition is fundamental to quantitative analysis of nutrient cycling in terrestrial ecosystems. Plant litter qualities, soil qualities, and environmental conditions are discussed as main impact factors of decomposition process in this section. Decomposition is one of most important processes that accounts for carbon and nutrient cycling on planet Earth. Decomposition or litter mass loss is regarded as the sum of CO_2 release and leaching of compounds, including both C compounds. Organic compounds in residues are classified into soluble components, hemicelluloses, cellulose, and lignin based on molecular size, solubility and primary constituent. Litter decomposition is complex and involves physical, chemical, and biological processes. It generally follows a sequential pattern with different classes of organic compounds dominating the decay process as it proceeds. When plant parts fall onto the soil surface, soluble organic substances such as sugars, phenolic, hydrocarbons, and glycerides are leached rapidly by water. This process is highly affected by climate conditions. At the same time, under soil microbial effects and external forces (such as wind, rain and cultivation), large pieces of plant residues are physically broken down into small bits, which provide greater surface area for microbial colonization and attack. Under the action of rapidly growing microorganisms, some sugars, low-molecular-weight phenolics, and some nutrients are readily lost from the litter. Following this, the plant detritus (cellulose, hemicellulose and lignin) undergoes chemical alteration by microbes, encompassing both fungi and bacteria (Fioretto *et al.*, 2005).

The effectiveness of different sources of organic matter varies depending upon their physical and chemical nature, rate of nutrient cycling and release of nutrients. Many farmers cannot afford to buy chemical fertilizers, or fertilizers are not available when needed. The use of agroforestry practices can alleviate some of the problems of declining in soil fertility. Leguminous plants can produce large amount of foliages which can release nutrients to enhance soil fertility and increase yields (Albercht and Kandji, 2003).

Many farmers in Nigeria for example, cannot afford chemical fertilizers and even those who can afford, cannot access the fertilizer when needed, because they are relatively unavailable or scarce. However, the use of agroforestry tree species which fix nutrients can at least alleviate some of the problems of declining soil fertility. Hence, nitrogen fixing agroforestry trees could be used to complement the improvement of soil for better yield of crops. Chemical compositions of the leafy biomass which are been determine by biological and environmental factors (such as decomposers, quality of litter, temperature and moisture etc.) are also vital area of concern as far as decomposition and release of nutrients are concern.

Study and research on macro nutrients contents and the soil composition status will assist in planning to improve the richness of the arboretum for economic, ecological, educational, recreational and research purposes. Moreover, the leafy biomass of some of the leguminous agroforestry trees within the arboretum can also be used to improve the soil quality of an improved or increased crop production. Leaves and pruning of some agroforestry trees incorporated or applied to the soil have the chance to improve the yield of many crops (as a result of nitrogen that will be released as nutrient through the leaves after decomposition) trees (Ajayi *et al.,* 2007). However, leguminous agroforestry trees can produce large amount of foliages which can release nutrients to enhance high soil productivity and increase yield (Albercht and kandji, 2003).

Litter decomposition plays a crucial role in the budget of forest ecosystem where vegetation depends mainly on the recycling of nutrient contained in the plant detritus. During the process, litter fall and decomposition is influenced by environmental factors and also by physical and chemical properties of plant parts such as stem wood, leaves, root etc. (Temel, 2003; Oyebamiji *et al.,* 2017). Litter fall is a fundamental process in the nutrient cycling and it is the main means of transfer of organic matter and mineral element from vegetation to the soil surface (Reginal *et al.,* 1999). Litter fall has also been described as a major pathway for the return of organic matter and nutrients from aerial parts of the plant community to the soil surface. Decomposition is a key process in the nutrient cycling and formation of soil organic matter (Berg and McClaugherty, 2002). The decomposition of leaf litters is a major source of nutrient in forest ecosystem (Temel, 2003).

MATERIALS AND METHODS

The Study Area

The research was conducted at Forest Arboretum of the Department of Forestry and Wildlife Management Federal University Dutsinma, Katsina State Nigeria. The area lies between (Latitude 8^0 29 N, Longitude 4^0 35 E and 307 meters above sea level. It was conducted in 2018 during dry seasons. Dutsin-ma is characterized by an annual rainfall of 1,186 mm while the mean annual temperature and relative humidity are 29^0 and 85 % respectively. The soil is well drained and the other is Alfisols belonging to the Tanke series (23). The underlying geology is made of sand stone, ranging from fine to coarse grained light brown colour. The dominant soil types include; sand, silt, clay and textural class (Lukman, 2018).

Soil sample collection

A plot of 50x50 meters was measured and trees were counted, soil samples were randomly collected from five locations at the depth of (0-30 cm) both from Arboretum and adjacent agricultural farm for physical and chemical analysis which include: Sand, silt, clay and, textural class, pH, organic carbon, total nitrogen and available phosphorus respectively. Prior to the commencement of the experiment using standard methods. Total nitrogen was analyzed by Macro-Kjeldahi digestion, followed by distillation and titration (Brandstreet, 1965; Anderson and Ingram, 1993). Ammonium was determined by the salicylate-hypochlorite colorimetric method (Anderson and Ingram, 1993) whereas NO_3^- plus nitrate (NO_2) was determined by cadmium reduction method (Dorich and Nelson, 1984).

Procedure

Plant materials were collected from *Faidherbia albida, Leuceana leucocephela, Senna siamen, Gliricidia sepium, Albizia lebbeck*. Five trees were randomly selected from each selected tree species out of which the leaves were collected. In each of the collected samples was pooled /bulked together while composite samples will also be taken.

The leafy biomass was air- dried and the sample was grounded and passed through a sieve of 2 mm size. Then, 2.0 g of each sample of the selected species was put into a digestion flask which was washed with distilled water.10 ml of 4 % perchloric acid ($HCLO_4$) was added to the samples under a fume cupboard. The contents were mixed and heated strongly on digestion block under the $HCLO_4$ fume cupboard.

The contents were allowed to cool and then 50 ml of distilled water was then added. The solution was transferred into a 100 ml Pyrex volumetric flask. The volume was made up to mark with distilled water. Then the solution was stored in plastic bottles and labeled for analysis. The digested sample solutions of plants were subjected to laboratory analysis to determine the Total Nitrogen (N), Potassium (K), Calcium (Ca), Magnesium (Mg), and Sodium (Na). Total Nitrogen was determined by Macro-Kjeldahl method as described by Jackson (1985) Phosphorus was detemined by Vanadomolybdo Phosphoric yellow colour as described by Kitson and Milton (1994).

RESULTS

Soil physical and chemical properties of the study area

The results of the physical, chemical properties and exchangeable bases (cations) of the soils type on arboretum and adjacent agricultural farm soils were presented, (Table 1) where the soil physical and chemical properties revealed that arboretum had 780 g/kg sand, 100 g/kg silt and 120 g/kg clay while chemical properties also showed that pH had 6.20 organic carbon 7.00g/kg, total nitrogen 0.42 g/kg, carbon to nitrogen ratio 16:67 and available phosphorus 3.10g/kg respectively. However, soil exchangeable bases/cations were observed to have 2.70 mg/kg calcium, 0.50 mg/kg magnesium, 0.31 mg/kg potassium and 0.12 mg/kg sodium. Furthermore, it was also observed that adjacent agricultural farm soil physical and chemical properties had 820 g/kg sand, 80 g/kg silt and 120 g/kg clay while chemical properties also showed that pH had 6.10, organic carbon 5.00 g/kg total nitrogen 0.28 k/kg carbon to nitrogen ratio 17:86 and available phosphorus 2.20 g/kg respectively. Moreover, soil exchangeable bases/cations were observed to have 2.12 mg/kg in calcium, 0.61 mg/kg in magnesium, 0.34 mg/kg in potassium and 0.11 m/kg sodium respectively (Table 1).

Table 1: Physical, chemical properties and exchangeable bases of the soils

Soils type	Particle size (g/kg)				Chemical properties					Exchangeable (mg/kg)			bases
	Sand	Silt	Clay	Textural class	pH	Organic carbon (g/kg)	Total nitrogen	C: N	Available phosphorus (mg/kg)	Ca	Mg	K	Na
Arboretum	780	100	120	Loamy sand	6.20	7.00	0.42	16:67	3.10	2.70	0.50	0.31	0.12
Adjacent Agricultural farm	820	80	100	Loamy sand	6.10	5.00	0.28	17:86	2.20	2.12	0.61	0.34	0.11

N:C: Nitrogen carbon ratio; **K:** Potassium; **Ca:** Calcium; **Mg:** Magnesium; **Na:** Sodium

Chemical composition/concentration of the selected agroforestry tree species

Faidherbia albida was observed to have significantly higher values (77.43a, 21.51a and 14.81a) in carbon, C:N ratio and PP:N ratio, while *Leuceana leucocephala* alsohad significantly higher value (20.00a) in cellulose than the other selected leafy biomass. However, *Senna siamen* was noticed to have significantly higher value (0.41a) in polyphenol, whereas *Gliricidia sepium* had (4.10a) in nitrogen than the other selected leafy biomass. *Albizia lebbeck* was discovered to have significantly higher values (15.59a, 54.29a, 4.15a and 4.22a) in lignin, lignin to polyphenol ratio, lignin to nitrogen ratio and lignin plus polyphone to nitrogen ratio respectively than in other selected agroforestry tree species leafy biomass (Table 2).

Table 2: Mean chemical composition/concentration of the selected leafy biomass of agroforestry tree species

Spp	N	C	C: N	L	PP	L: PP	L: N	PP: N	(L+PP:N	Cellulose
FA	3.60b	77.43a	21.51a	5.41e	0.24c	22.26d	1.50e	14.81a	1.50e	12.16c
LL	3.20c	50.73d	15.86d	12.26b	0.37b	38.19b	3.83b	9.97d	3.93b	20.00a
SS	3.60b	58.75c	16.32c	6.33d	0.41a	15.14c	1.76d	8.61e	1.87d	12.16c
GS	4.10a	48.04e	11.72e	11.11c	0.32c	29.71c	2.71c	10.96c	2.80c	6.17d
AL	3.75b	74.76b	19.94b	15.58a	0.24d	54.29a	4.15a	13.07b	4.22a	17.33b

N: Nitrogen; **C:** Carbon; **C:N:** Carbon to nitrogen ratio; **L:** Lignin; **PP:** Polyphenol; **L:PP:** Lignin to polyphenol ratio; **L:N:** Lignin to nitrogen ratio; **PP:N:** Polyphenol to nitrogen ratio; **(L+PP):N:** Lignin plus polyphenol ratio nitrogen

DISCUSSION

The results of the study revealed that nitrogen and organic carbon in Arboretum soil was slightly higher than that of adjacent agricultural farm. These soil chemical properties in the Arboretum soil actually determined the quality of the soil, owing to the influence of nutrient contents resident in it as a result of biomass and litter that has decomposed and in turn added nutrients to the soil as fertility improvement. This is in line with Oyebamiji *et al.* (2017) who stated that, biomass decomposition increases the nutrient content of the soil per period of time. Similarly, according to Smithson and Giller (2002) who reported that the higher nutrients composition of the Arboretum can be due to reduced leaching at the arboretum floor due to canopy cover and thereby preventing direct run-off of water in form of erosion.

Though, it has been documented that agroforestry remain one of the important and efficient means by which nutrients leaching can be reduced (Odiwe *et al.,* 2016). This leafy biomass optimally functioned as nutrient fixer and agents of leaching control because they were allowed to decompose without being fed on by animals. The University arboretum is a restricted area for research, and this has led it to have minimum entrance and zero encroachment. The soil types of arboretum and adjacent agricultural farm land belong to loamy sand textural class; so also, the soils exhibit weak acidity respectively.The chemical composition or concentration of the selected leafy biomass showed that *Gliricidia sepium* among other biomass decomposed faster to release mineral nutrients due to its high nitrogen and low carbon to nitrogen ratio contents. The better performance of *Gliricidia sepium* in terms of nutrients release agrees with Oyebamiji *et al.* (2017a).

Although, the results of the nutrients composition analysis of the leafy biomass were found to be significantly different from one another, it has however been established that *Gliricidia sepium*, *Leuceana leucocephala* and *Senna siamen* are excellent Nitrogen fixer (Budelman, 1989). The polyphonol content of the leafy biomass are generally low and still significantly different though, this might cause a faster release of the nitrogen content of the leafy biomass. Decomposition and quick nitrogen release have been found to be enhanced by lignin and polyphenol (Makaza and shako, 2013). Furthermore, the value of the macro nutrient in Nitrogen for *Albizia lebbeck* in the present study is below the macro nutrient of nitrogen in *Albizia lebbeck* (5.60) obtained elsewhere Bichi, (2012). Similarly, both phosphorus (370.2 ppm) and potasium (1.34 %) of the present study were lower than those obtained in Bichi (2012). This is an indication of disparity in the innate macro nutrient of the two study areas. However, it is noteworthy that all the biomass species have significant amount of the macro nutrients required by agroforestry.

CONCLUSION AND RECOMMENDATIONS

It was observed that *Gliricidia sepium and Albizia lebbeck* contained the higher mean concentration of macro nutrients, nitrogen, phosphorus, magnesium and sodium which are pertinent in plant development. Arboretum has better soil physical, chemical and exchangeable bases composition than adjacent agricultural farm. The soil types were also noted to be nearer neutral, meaning that, contain weak acidity and loamy sand in nature. Furthermore, *Albizia lebbeck* and *Faidherbia albida* were found to be superior in terms of the chemical decomposition, while *Gliricidia sepium* was higher in nitrogen release among all the selected leafy biomass.

Due to high fertility and chemical content in the Arboretum soil, it is therefore advisable that it should be used for agroforestry activities leafy biomass in forms of alley cropping. Moreover, *Gliricidia sepium, Albizia lebbeck and Faidherbia albida* should be employed or considered while selecting species for augmenting soil potential and/ or improving soil fertility for various agroforestry activities.Agroforestry trees that are rich in nitrogen and other macro nutrient capacity should be used as alternate fertilizer to inorganic fertilizer that are relatively scarce, costly and adversely affecting soil improvement.

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AN ASSESSMENT OF THE EFFECT OF FLOODING ON LIVESTOCK PRODUCTION IN HADEJIA, NIGERIA.

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ABSTRACT
This study was conducted to assess the effect of flooding on livestock production in Hadejia Local Government Area of Jigawa State, Nigeria and to offer possible solution to the problems. Two hundred (200) well-structured questionnaires were designed and allotted to 200 victims of flood as respondents. The result showed that, majority of respondents in the study area were males and married, with a wide age range 20 – 60 years. Majority of the farmers kept their flock under intensive and semi-intensive systems of production, and they experienced challenges during flooding period, especially mid and late of rainy season. During this period most of the farmers lost their animals, due to diseases, death, suffocation and feeding problems that were brought about by the menace. The ultimate effects of floods include the agony of survivors, the spread of an epidemic, non-accessibility of essential commodities, medicines, and loss of the dwellings which compel the affected people to perceive such floods as the most feared among the natural disasters being faced by mankind. This can be prevented or minimized when the incidences of floods are not catching individuals and communities by surprise and unaware in a repeatedly exasperating way and causing disruption of social activities, damages of infrastructure and even death of people and livestock. Also more attention is needed to be paid to the flooding by both the community, the government and any relevant stakeholder.
Keywords: *Farmers, Flooding, Hadejia, Livestock, Production*

INTRODUCTION
The world has had already witnessed devastating effects on properties and livelihoods as well as economic losses due to floods than any other hazard (Armah *et al*., 2010). A flood is a natural event that can have far reaching effects on people and the environment. Put simply, a flood is too much water in the 'wrong' place. Flooding occurs most commonly from heavy rain fall when natural water courses do not have the capacity to convey excess water. Flooding is the most common of all environmental hazards and it regularly claims over 20,000 lives per year and adversely affects around 75 million people world-wide (Adewuyi and Olofin, 2014; Akukwe and Ogbodo, 2015). In Nigeria, the pattern is similar with the rest of world. Flooding in various parts of Nigeria have forced millions of people from their homes, destroyed businesses, polluted water resources and increased the risk of diseases (Bastakoti *et al*., 2014; Obeta, 2014; Emeriobeole 2015). Emeriobeole (2015) asserts that floods are among the most devastating natural disasters in the world, claiming more lives and causing more property damage than anyone would imagine. According to him, in Nigeria though not leading in claiming lives, flood affects and displaces more people than any other disaster. It also causes more damage to properties and at least 20 percent of the population is at the risk from one form of flooding or another. Floods often occur in Hadejia and other part of Jigawa State. From the year 2020 and 2022, Hadejia was affected by the terrible floods which happened to be severe ones as many towns and villages under the emirate council were affected by floods, while causing havoc in the entire state. Further, many hectares of land under cropping well as animal life got affected by floods in these years, which leads to the poor economy especially among the livestock-rearers, who depend, solely, on animals for their livelihood. (Mishra, 2017). Therefore, it was thought essential to document the impact

of the flood on the economic condition of livestock-rearers as well as livestock production in Hadejia local government area.

MATERIALS AND METHODS

The study was conducted at Hadejia Local Government Area of Jigawa State, Nigeria (12^0 27'N / 10^0 2'E and $12^0$45'N / 10^0 033'E). Hadejia has an area of 32km^2 and a population density of 4,356 people/km^2, the population was approximately 105,628 in National Census of 2006. It falls into the ecological zone of Sahel savannah, characterized by a short rainy season with annual rainfall of about 200mm to 600mm, during the period of late May to September. It has an average low temperature during cold between 15^{0}C and 21^{0}C and temperatures between 27^{0}C and 42^{0}C during hot season. The relatively humidity is very low often between 10% to 30% in January and 60% to 80% during the rainy season. The town lies to the north of the Hadejia River and upstream of the Hadejia Nguru wetlands. Hadejia Local Government Area has a total of Eleven (11) wards which include Atafi, Dubantu, Kasuwar Kuda, Kasuwar Qofa, Majema, Matsaro, Rumfa, Sabon-Garu, Yankoli and Yayari wards. The people of Hadejia are largely Muslim, although some follow indigenous belief system. Most of the people of Hadejia are Hausa and Fulani by tribe. Their occupations are farming, rearing of animals, fishing, trading and civil services (Bird Life International, 2021; Muhammad *et al*., 2023). The area is conducive for livestock production, the common livestock species in the area includes; cattle, sheep, goat, rabbit and poultry.

Data collection and analysis

Data was collected through the use of two hundred (200) structured questionnaires and organized informative oral interview with selected respondents using their local language (Hausa language). Data collected was stored in MS excel and later analyzed using simple descriptive statistics.

RESULTS AND DISCUSSIONS

Distribution of the respondents according to socio-economic characteristics

The distribution of the respondents according to socio-economic characteristics were given in table 1, where (93%) of the respondent were male and (7%) were female. Most (36%) of the respondent were in the range of 20-40 years of age and mostly married (64%) with low to mid-level of formal education. Most of the respondents (93%) were male indicating that males are more actively involved in livestock farming in the study area. The age of respondents were highest in the range of 20–40 years (36%) indicating most of the farmers were young. Majority (64%) were married and have some form of formal and qur'anic education. Qur'anic education (33%), adult education (13%), primary (20%), secondary (24%), and tertiary (9%). Qur'anic education could be describe as literate in terms of reading and writing.

Table 1. Distribution of the respondents according to socio-economic characteristics

Socio-economic characteristics	Frequency	Percentage (%)
Sex		
Male	186	93.0
Female	14	7.0
Age		
< 20years	54	27.0
20-40	72	36.0
41-60	34	17.0
Above 60	40	20.0
Marital status		
Single	64	32.0
Married	128	64.0
Divorced	6	3.00
Widower	2	1.0
Educational background		
Qur'anic	68	34.0
Adult education	26	13.0
Primary	40	20.0
Secondary	48	24.0
Tertiary	18	9.0

Distribution of the respondent based on livestock destroyed, action taken, number of animals destroyed and Destruction cause to the animal.

Table 2 shows the distribution of the respondents based on livestock destroyed, action taken, number of animals destroyed and destruction to the animals. The study shows that, nineteen percent (19%) lost their sheep, (18%) cattle, (18%) goat, (12%) poultry, (14%) sheep and goat, (15%) sheep, goat and cattle, (4%) combination of all and the action taken from the respondent was (22%) slaughtered, (22%) sold, (18%) attend veterinary clinic and (38%) lost animal. According to the respondents the destruction cause to the animals was (37%) death, (38%) diseases, (20%) suffocation, and (5%) lost. The number of animals destroyed per household of the respondents was 1-5 (67%), 6-10 (20%), 10-20 (8%), above 20 (5%).

Table 2. Distribution of the respondent based on livestock destroyed, Action taken, number of animals destroyed and Destruction to the animal.

Variable	Frequency	Percentage
Livestock destroyed		
Goat only	36	18.0
Sheep only	38	19.0
Cattle only	36	18.0
Camel	0	0.0
Poultry only	24	12.0
Sheep and goat	28	14.0
Sheep, goat and cattle	30	15.0
Combination of all	8	4.0
Action taken		
Slaughter	44	22.0
Selling	44	22.0
Animal Lost	76	38.0
Attend veterinary clinic	36	18.0
Destruction to the animal		
Death	74	37.0
Disease	76	38.0
Suffocation	40	20.0
Others	10	5.0
Number of animals destroyed		
0-5	134	67.0
6-10	40	20.0
10-20	16	8.0
Above 20	10	5.0

Distribution of respondent based on effect of flooding.

Table 3 shows the effect of flooding in causing destruction of lives and properties. The study shows that, there was (10%) loss of lives, (77%) damage to roads and (25%) lost of property. All respondent (100%) Lost their farm land, some confirmed flooding caused erosion (66%) and (95%) livestock destruction.

Table 3. Distribution of the respondents based on effect of flooding

Variable	Frequency	Percentage
Loss of life		
Yes	20	10.0
No	180	190.0
Loss of property		
Yes	50	25.0
No	150	75.0
Lead to bad road		
Yes	154	77.0
No	46	23.0

Loss of farm land		
Yes	200	100.0
No	0	0.0
Caused erosion		
Yes	132	66.0
No	68	34.0
Livestock destruction		
Yes	190	95.0
No	10	5.0

Thousands of people die, millions become homeless, and properties and infrastructures are greatly damaged by the calamities of flood every year all over the world (Obeta, 2014). The effect of flooding in study area was worst in terms of losing of homes, properties, infrastructure, livestock as well as farmland. The study revealed that, there were lost of farmlands, lives, properties, damage roads, erosions, livestock destructions in the study area, which agrees with Emeriobeole (2015) that asserts floods to be among the most devastating natural disasters in the world, claiming more lives and causing more property damage than anyone would imagine. The result was also in line with the findings of Obebi (2013) who reported for instance, Abia, Adamawa and Akwa Ibom states that witnessed heavy downpour and rain storm which affected about 5,000 people. Explaining further, Obebi (2013) confirms that in the same year, about 12,300 people were displaced by torrential rain which destroyed livestock and farmlands, damaged properties and submerged buildings in Zamfara state.

CONCLUSION

It is concluded that most of livestock farmers in Hadejia Local Government Area kept different types of livestock, and were faced with a lots of problems. Among other disasters, floods have escalated intensive harm to their crops and livestock. During this period most of the farmers lost their animals, due to diseases, death, suffocation and feeding problems. The ultimate effects of floods include the agony of survivors, the spread of an epidemic, non-accessibility of essential commodities, medicines, and loss of the dwellings which compel the affected people to perceive such floods as the most feared among the natural disasters being faced by mankind. This can be prevented or minimized when the incidences of floods are not catching individuals and communities by surprise and unaware in a repeatedly exasperating way and causing disruption of social activities, damages of infrastructure and even death of people and livestock. Also more attention is needed to be paid to the flooding by both the community, the government and any relevant stakeholder.

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IMPLICATIONS OF HERDERS AND CATTLE INFILTRATION ON BIODIVERSITY CONSERVATION IN OLD OYO NATIONAL PARK, NIGERIA

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ABSTRACT
Despite being a protected area, Old Oyo National Park (OONP) still experiences myriads of illegal activities. The study highlighted the implications of herders and cattle infiltration into OONP. The study driven by qualitative research approach with document analysis, unearth the recurring challenges that have been the obstacles to achieving sustainability and conservation of OONP biodiversity. The study showed that the most prevalent challenges to the conservation of natural resources in the study area was illegal grazing. The study recommended the establishment of cattle grazing reserves as well as strict adherence to all existing local, national and international policies regarding ranching and pastoralism.
Keywords: *Herders, Conservation, Biodiversity, Cattle infiltration, Old Oyo National Park*

INTRODUCTION
Unregulated nomadic grazing, apart from its potential to increase insecurity and conflicts, also has an adverse impact on the environment. Over grazing causes severe damage to the environment such as the exposure of fragile soils leading to severe erosion and subsequent downstream siltation and the introduction of aggressive weeds by the cattle (Asadu, 1999). Pastoralists are people whose major source of livelihood is livestock herding (Bhasin, 2011). In Nigeria, migration is part of a comprehensive economic strategy (NEST and Tegler, 2011). The movement of the pastoralists is governed by livelihood norms associated with the needs of their cattle for pasture. In different countries in Africa, nomadic pastoralists are usually a mix of both the indigenous ones and those who migrated from other neighbouring African countries in search of water and pasture. The latter movement is known as transhumance, even though the movement of the nomadic pastoralists within a country is also regarded as transhumance by some authors (Agyemang, 2017). However, in recent times, the practice has resulted in severe conflicts wherever nomadic pastoralists and their herds pass through or attempt to settle temporarily. The purpose of this review was therefore to highlight the implications of herders and cattle infiltration into Old Oyo National Park, Nigeria.

MATERIALS AND METHOD
Study Area
Old Oyo National Park (OONP) has a total land mass of 2512 km^2 and is located in the South Western part of Nigeria, specifically Northern part of Oyo State. OONP is geographically located between latitudes 8°15' and 9°.00'N of the equator and longitudes 3°35' and 4°42'E of the Greenwich meridian.

Data Collection and Analysis
The qualitative research approach was utilized for the study. This was due to the fact that the researcher collected and examined numerous secondary data such as previously published articles, public reports (Creswell, 2009; Narayanan, 2015) related to fauna and flora conservation. The research was mainly driven desk research and interpretative document analysis were the main research methods that guided the finding, selecting and rigorous examination of important documents. The secondary data was analyzed quantitatively. Categories and themes were generated to give detailed comprehension of the secondary data reviewed (Denzin and Lincoln, 1994). Finally, the facts were evaluated and presented using descriptive statistics.

RESULTS

Table 1 below showed that most occurring offence in Old Oyo National Park was grazing with overall total of 445. Highest record of illegal activities occurred in year 2018 (150), while the least record of illegal activities occurred in year 2014 (45). Hunting activity (225) was more prominent after grazing in Old Oyo National Park.

Table 1: Records of Illegal Activities in Old Oyo National Park from 2014-2021

Offences	Arrests								
	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Total**
Hunting	13	33	23	31	64	10	19	32	**225**
Grazing	5	21	42	50	79	104	81	63	**445**
Logging	7	6	6	2	-	-	3	3	**27**
Honey trapping	-	-	2	-	-	2	10	5	**19**
Mining	20	46	12	-	-	-	6	-	**84**
Farming	-	-	3	-	6	3	-	-	**12**
Fishing	-	-	-	2	1	-	-	5	**8**
Wandering	-	1	-	-	-	-	-	1	**2**
Total	**45**	**107**	**88**	**85**	**150**	**119**	**119**	**109**	

Source: Old Oyo National Park Research Unit

Furthermore, grazing activity was more pronounced when compared to hunting activity, as shown in Figure 1 below. For instance, in years 2006 (G= 42; H= 33), 2007 (G= 50; H= 33), 2008 (G= 79; H= 64), 2009 (G= 104; H= 10), 2010 (G=81; H= 19), 2011 (G= 47; H= 32), 2012 (G= 63; H= 0), 2013 (G= 61; H= 53), 2014 (G= 65; H= 24) and 2015 (G= 64; H= 24). On the other hand, hunting activity was more in years 2004 (H= 13; G= 5) and 2005 (H= 33; G= 21).

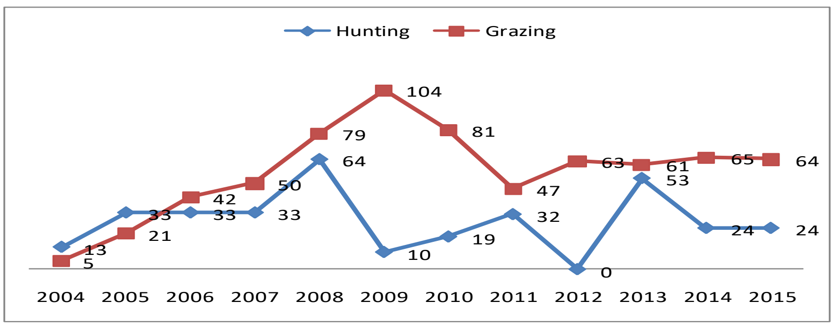

Figure 1: Arrests made on grazing and hunting activities in OONP, Nigeria
Source: Adapted from Old Oyo National Park Research Unit

DISCUSSION

Grazing, hunting, mining and logging were obviously the most engaged illegal activities in Old Oyo National Park. These may not be unconnected to the proximity of the Park to the locals as echoed by Hames (1988) and Alvard (1994) in Adedoyin *et al*. (2018) that most illegal activities occur near human settlements. Furthermore, the infiltration of herders and cattle into the Park is a huge threat on the conservation of biodiversity. Out of the twelve (12) years under review, illegal grazing occurred more in ten (10). This reveals how porous and unguarded the Park is. The implications of this is that fauna, flora and forms of life existing within the Park are prone to global warming through greenhouse emissions (Havlik, 2014); diseases transmission (either vertically or horizontally); as well as loss of lives (field staff). The evidence of intensive grazing is obvious in Old Oyo National Park as reflected by the crisscross of trampling marks, in some cases resulting in permanent tracks. Such level of grazing intensity will lead to the process of irreversible environmental degradation (such as soil surface compaction, erosion and invasion of non-native plant species) whereby the ecosystem is incapacitated to support regeneration.

CONCLUSION

Cattle grazing and rearing, as is being practiced currently in Nigeria, is not environmentally sustainable. Several gaps relating to lack of robust mechanism for stakeholders participation in land reform processes has exacerbated the spate of land grazing conflicts and disputes in Nigeria. Conservation managers should therefore devise means to drastically reduce incessant infiltrations into our National Parks.

RECOMMENDATIONS

i. There should be the establishment of cattle grazing reserves in the first instance, while the pastoralists and other stakeholders are being prepared to adopt the ranching method of cattle rearing.

ii. Both the federal and state governments should work together with National Environmental Standards and Regulations Enforcement Agency (NESREA) and the State Environmental Protection Agencies in creating the grazing reserves and eventually, the ranches to ensure that existing environmental legislation are complied with.

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ASSESSMENT OF HEAVY METAL CONTENT IN SOIL AROUND CASSAVA PROCESSING MILL AT OJA OBA, IGBOORA, NIGERIA

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ABSTRACT
The level of heavy metals concentration in the soil around Cassava Processing Mill at Oja Oba in Igboora, Nigeria was assessed around Oyo State College of Agriculture and Technology, Igboora, Nigeria. Soil samples were collected at a distance of 0-10, 10-20, 20-30, 30-40, 40-50, 50-60m away from the point of discharge of the cassava processing effluent. However, the control sample taken from the adjacent soil that did not receive cassava processing effluent. Three samples were collected from each distance range and analyzed for Pb, Mn and Cu after digesting the samples with nitric-perchloric acid at the ratio of 2:1. The data collected were subjected to ANOVA and means separated using DMRT at 5% level of probability. The concentration of Pb significantly varied ranging from 5.00-16.07 mg kg^{-1}; Mn (82.13-183.33 mg kg^{-1}) and Cu (4.94-12.83mg kg^{-1}). These values were significantly different at 5% level of probability except for Mn. The concentration of these metals were found to increase with the distance away from the point of discharge of the cassava processing effluent except Mn. Comparing the concentration of Pb, Mn and Cu in the study area with the World Health Organization (WHO) permissible level in soil, the concentration of Pb, Mn and Cu were found to be within the safety limit. This implies that the soil around the cassava processing mill at Oja Oba, Igboora is still contamination free but, caution must be taken not to load the soil beyond the safety limit to avoid potential water contamination in the study area.

Keywords: *Cassava effluents, environment, heavy metals, pollution, soil properties*

INTRODUCTION
Cassava processing involves wastes generation in different zones including peels from the peelings stage, cassava mill effluents from the dewatering/pressing zone and gaseous emissions from the frying stage (Ohimain *et al*., 2013). The liquid waste popularly known as cassava mill effluents is generated in the grating and dewatering zone and it account for about 16% of total weight of cassava tuber (Ohimain *et al*., 2013). The wastes are discharged into the environment without any form of treatment (Izah *et al*., 2017). The toxicity of cassava mill effluent is basically associated with its acidic pH and cyanide content. In acidic soils, plants are likely to take up toxic metals, which may prevent seed germination or eventual death (Olorunfemi *et al*., 2008). When these cassava mill effluents are improperly disposed, they generate offensive odour and unsightly scene (Okafor, 2008).

The discharge of waste products and contaminants into surface runoff get into rivers through drainage systems, leaching into liquid spills, groundwater and wastewater discharges and littering. Soil contamination in our case occurs when drains from cassava processing factory are released by spill or underground leakage. This cassava effluent has a negative effect on our environment. Effluent wastes contain varying concentration of heavy metals either as simple metals or complexes (Agwa *et al*., 2014). The increasing level of heavy metals in the environment from various anthropogenic sources like cassava mill effluent should be a source of concern for environmentalists (Iwegbue, 2007; Osakwe and Egharevba, 2008). These heavy metals that are released into the environment tend to persist indefinitely, accumulating in living tissues through food chain causing diseases to man (Enerjiofi and Ajuzie, 2012).

Therefore, the objective of this study was to evaluate Lead (Pb), Manganese (Mn) and Copper (Cu) status of the soil around cassava processing mill at Oja-Oba, Igboora, Nigeria.

MATERIALS

Soil, Cassava extract, Metals e.g. lead, manganese and copper, Nitric acid, Perchloric acid, Volumetric flask and Measuring cylinder

METHODS

Study Location

The study was conducted in the Oyo State College of Agriculture and Technology, Igboora Oyo State, Nigeria. Igboora is located between Latitude 7^0 40' N and Longitude 3^0 30' E, 27.5m above the sea level. The natural climate is characterized by both the wet and dry seasons with the rainy season beginning from April lasting till October while the dry season begins from October and ends in April.

Soil Sampling and Analysis

Surface samples (0-20cm) were collected at the site from 0 -10m, 10-20m, 20-30m, 30-40m, 40-50m, 50 - 60m away from the point of discharge of the effluent. The control was taken from the adjacent field (plot where there is no cassava effluent discharge). Three soil sample collection. The sample collected were air dried and passed through a 2mm sieve.

The dried soil samples were digested using nitric-perchloric acid (2:1). The dried soil sample were digested using 10ml of 2:1 by volume of nitri-perchloric acid until dense white fumes appeared. The digest was allowed to cool and some quantity of distilled water was added to the digest. The solution was filtered into a 50ml volumetric flask and diluted to volume (SSA, 1996). The amount of Pb, Mn, and Cu in the digest was then determined using atomic absorption spectrophotometer (AAS).

Statistical Analysis

All data collected were analyzed using ANOVA and means separated using Duncan multiple range test (DMRT).

RESULTS AND DISCUSSION

Concentration of Lead (Pb) in soil around cassava processing mill at Oja Oba

The concentration of Pb in the soil around the cassava processing mill at Oja Oba is presented in Table1. The concentration of Pb in the soil varied greatly ranging from 5.00 to 16.07 mg kg^{-1}. The highest amount of Pb (16.07 mg kg^{-1}) at the Cassava processing mill was observed in the control sample while the lowest value (5.00 mg kg^{-1}) was recorded in the samples taken between 0-10m farther away from the point of discharge of the cassava effluent. The results also showed that the concentration of Pb increased with the distance away from the point of discharge of the cassava processing effluent. However, it is important to know that the amount of Pb observed in the soil fell below the maximum permissible level of Pb in soil (85 mg kg^{-1}) by the World Health Organization (WHO).

The increase in the concentration of Pb as the distance increased from the point of discharge may be due to the slope nature of the study area. Soil nutrients are known to move down the slope.

Concentration of Manganese (Mn) in soil around cassava processing mill at Oja Oba

The concentration of Mn in the soil around cassava processing mill at Oja Oba is presented in Table 2. The results showed that there was no significant difference amongst the treatment means. However, just like it was observed for Pb, the highest amount of Mn in this soil was recorded in the control (183.33 mg kg^{-1}) while the lowest value of 82.13 mg kg^{-1} was observed in the soil collected between 10-20m away from the point of discharge of the cassava processing effluent. Contrary to Pb that showed an increase with distance as you move away from the point of discharge, Mn did not follow a particular trend.

The concentration of Mn also fell below the permissible level of Mn in soil (2000 mg kg^{-1}) given by WHO.

Concentration of Copper (Cu) in soil around cassava processing mill at Oja Oba

The results in Table 3 showed the concentrations of Cu in the soil around cassava processing mill at Oja Oba. The concentration of Cu in this soil varied greatly with the distance including the control. The highest amount of Cu (12.83 mg kg^{-1}) was recorded in the control while the lowest value of 4.94 mg kg^{-1} was observed from 0-10m from the point of discharge of the cassava processing effluent. The concentration of Cu increased with distance as observed for Pb. The amount of Cu recorded in all the samples was below the WHO recommended permissible level of Cu (36 mg kg^{-1}) in soil.

Table 1: Concentration of Pb, Mn and Cu (mg kg^{-1}) in soil around cassava processing mill at Oja Oba, Igboora.

Treatment (m)	Pb (mg kg^{-1})	Mn (mg kg^{-1})	Cu (g kg^{-1})
0 – 10	5.00c	103.20a	4.94b
10 – 20	6.67bc	82.13a	4.99b
20 – 30	6.67bc	116.07a	5.15b
30 – 40	10.87ab	171.00a	5.53b

40 – 50	9.73bc	127.00a	5.06b
50 – 60	10.93ab	141.40a	5.46b
Control	16.07a	183.33a	12.83a

Means with the same letters are not significantly different at 5% level of probability using DMRT

CONCLUSION AND RECOMMENDATION

The study showed that all the metals evaluated were present at the cassava processing mill at Oja Oba, Igboora. The concentration of Pb and Cu were observed to increase with distance away from the point of discharge of the cassava processing effluent except for Mn. The concentration of Pb, Mn and Cu in the study area are still within the permissible limit of WHO. It was also observed from the study that cassava processing effluent could reduce the concentration of these metals in the soil. Therefore, further study should be conducted on the impact of cassava processing effluent on heavy metals availability in soil.

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OPEN GROWN TREES (OGTS) AND SUSTAINABLE LIVELIHOOD DEVELOPMENT: A REVIEW

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ABSTRACT
Open Grown Trees (OGTs) are reliable source of income for rural farmers and populace; and very critical for biodiversity conservation, food security interventions and livelihoods development. The diversity of tree species available on farmlands help to sustain the farming system and also uplift the economy of rural households. This paper highlights the Contributions of OGTs to Rural Livelihood Development; provisions of non-financial benefits obtainable on farmlands and the Non-Timber Forest Products (NTFPs).
Keywords: *Farm trees, farmers, NTFPs, rural development, sustainable livelihood*

INTRODUCTION
As human population increases, the demand for forest products also increases. Therefore, to meet these demands, several tree planting initiatives were encouraged as a potential strategy to meet the forest product needs of growing populations (Bergsten et al., 2014). The 1970's environmental degradation provoked a rush of aid to countries hit by drought and desertification. Within this period, rainforests were also threatened through logging and agricultural expansion received unprecedented consideration and tree planting was encouraged (Aju, 2012,). In the 1980's, interest also mounted in Non-Timber Forest Products (NTFPs) which were previously relegated to the status of minor products. It was at this time that trees especially 'trees outside the forest' (T.O.F), a phrase coined in 1995 (FAO, 2001), began to be considered in terms of their contribution to the well-being of people and their environment.

What are Open Grown Trees (OGTs)?
Open Grown Trees (OGTs) can be described as trees growing outside of officially designated forest areas, such as on agricultural lands, along railway lines, in orchards, on parklands, along roads, ponds and homesteads. It is difficult to measure OGT's economic contribution at the local and regional levels because of its diversity (both in terms of the resource itself and where it occurs). Over the years, farmers have tried to retain, protect, plant and manage trees on their farmlands (Onilude, 2018). These trees are referred to as the T.O.F and also known as the OGTs. They comprise all trees excluded from the definition of forest and other wooded lands (FAO 2001; Bellefontaine et al., 2002; Yadav et al., 2020). OGTs are important natural resources that contribute to the livelihood of people in many localities and have significant importance and perform a number of ecological, economic and socio-cultural functions (Schnell et al., 2015; Yadav et al., 2020; Onilude, 2018, 2021).

OGTs on farmland form an important part of the farm landscape that is very important for sustainable land use, carbon sink and organic matter, biodiversity conservation for both above and below ground and informing food security interventions (Endale *et al*., 2017). OGTs can contribute to the ecological and economic functions of an ecosystem. It can provide wood fuel, promote dry seasonal flow, stabilize soils, and ameliorate the micro-environment making it more conducive for enhanced biodiversity of flora and fauna in an area or/and farmlands (Endale *et al*., 2017).

The diversity of tree species available on farmlands help to sustain the farming system and also uplift the economy of rural households (Garforth et al., 1999). The production and retention of tree species on farmlands by the farmers in Saki, Ibadan, Oyo and Ogbomoso agricultural zone of Oyo State, Nigeria earned about ₦33,500; ₦22,666; ₦34,083 and ₦26,000 monthly respectively (Onilude, 2021). Similarly, forest trees, agricultural crops and livestock are interwoven in Nepali farming system and thus sustainability of farming system depends on the continuous existence of tree resources on the farming system (Yadav et al., 2020).

Furthermore, there are several reports of tree species growing on farmlands in Nigeria (Ajake 2012; Aju 2012; Onilude 2018). These reports elucidated the significant importance of OGTs to rural livelihood development. Table 1 showed the non-financial benefits and Non-Timber forest Products (NTFPs) obtainable from the farmlands.

Table1: List of Non-timber Forest products and Non-financial benefits of OGTs on Farmlands

S/N	Non-financial Benefits	Non-timber Forest products
1	Shade	Fuel wood
2	Windbreaks	Sponges
3	Fencing	Leaves
4	Animal feed	Fruits
5	Soil improvement	Chewing
6	Fuel wood	Sticks
7	Construction materials	Vegetables
8	Stalk	Wildlife

Contributions of OGTs to Sustainable Livelihoods

The total contribution of trees on farmlands to livelihoods is difficult to quantify. A significant proportion of these products are consumed by those who collect them, with the amount or volume collected varying according to seasonality, access and options (Kunarattanapruk et al., 1995). The rural people often produce, process and sell forest products (e.g. making mats and baskets and selling fuel wood) in the absence of other employment opportunities, often as a part-time activity within farming households (Dewees and Scherr, 1996). However, the general contributions of OGTs to livelihood are summarized below:

1. Improved Food Security: Food security is a key element of livelihood. The majority of rural households in tropical countries, and a large proportion of urban households, depend on plant and animal products of forests to meet some parts of their nutritional, cooking and/or health needs (Byron and Arnold, 1999).
2. Reduced vulnerability: People who often live precariously, with no cushion against adversity. OGTs have an important role as a reserve or safety net, providing both subsistence and income in times of crop failure, shortfall, unemployment or hardship, or to meet exceptional needs. OGTs are sometimes used by farmers to help meet dietary shortfalls during particular seasons in the year.

Other contributions of OGTs may include:

3. Building soil carbon and soil organic matter
4. Providing a framework for both below and above ground diversity to flourish
5. Helping innovating diversified farm enterprises.
6. Providing shelter and fodder for all livestock
7. Having ecological, economic and socio-cultural values

The fundamental appeal of farm trees as T.O.F. is that, in addition to addressing environmental concerns such as deforestation and climate change (Kiyingi et al., 2016; Hemida and Adam, 2019), farm forestry realized as a tool for improving livelihoods of the rural communities through supplying wood products market (FAO, 2001), which could encourage the rural poor households to participate in establishment of farm trees and could improve their livelihoods and alleviate their poverty (Oksanen et al., 2003; Hemida and Adam, 2019).

CONCLUSION

Trees left on farmlands are consciously managed by farmers to form an integral part of the farming systems and have great impacts on forest management. The role of farmland trees as part of OGTs on rural livelihood is of great extent as farmers make valuable use of the tree resources on their farmland by getting both non-financial benefits as well as major NTFPs from the farmlands. However, the act of retaining trees on farmlands has the capacity to reduce the pressure which human population is mounting on the primary forest especially in the conserved natural forest ecosystem of Nigeria.

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ECONOMICS OF NON-TIMBER FOREST PRODUCT PRODUCTION IN IMO STATE, NIGERIA

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ABSTRACT

The trade-off between environmental quality and economic goods within the forest environment is raising a serious policy concern especially now that most forest is gradually lost to degradation. Productive operations within forest environment may be profitable with concomitant burden on the environment. The study examines the economics NTFPs production with data from 80 agro-forest prenures selected across the state using a two-stage sampling procedure and analyzed using cost and returns as well as simple descriptive statistic. The result presents a male dominated (52.5%) agri-forest prenure with secondary education and a mean forest area 1.92ha under NTFP production. There is net returns of ₦19,614.19/ha from leafy vegetables, like ukazi; (Gnetum africanum), utazi (Gangronem alatifolium) and uzuza (Piper guineense) with a rate of returns to capital of 1.76/ha, hence about ₦0.76 returns per hectare in every ₦1.00 total private cost per hectare in the forest environment. Again, a gross and net private margin of 0.657 and 0.534% respectively to the total cost of oil palm fruit harvest is made within the forest. This implies that there's a rate of return to operating expense and total capital invested of 65.7% and 53.4% respectively. Hence, for every ₦1.00 spent on operating expense in oil palm tree maintenance and fruit harvesting an additional ₦0.65 per agro-forest prenuers while ₦0.53 will be generated. The total private return of N189, 695.12 per farmer in snail production within the forest is a better improvement with a return to capital of 134.5%. There is a more than proportionate increase in return to capital invested of ₦1.35 with every ₦1.00 spent in snail production within the forest environment in the state. The result shows that the total social cost of ₦156,100.00 from all the productive operation within the forest environment in the state was higher than the social benefit ₦91,000.00 derived from the forest environment with a negative net social benefit (₦65,100.00). The use the forest for NTFP production is difficult to exclude other social benefits it has generated or derived from the outside the immediate private operations in the state. The study recommends that agro-forest prenures should intensify more wedges (transactional cost) against negative externalities in all their productive operations. This will increase the social benefit, reduce external cost thus sustain the net private gains in NTFP production in the state.

Keywords: *Economics, Non-Timber, Forest and Products and production*

INTRODUCTION

In Africa, more than two-third (2/3) of the people, which is about 600 million people, depend on forest resources either in a type of subsistence use or as source of revenue (Timko, *et al*., 2010). The forests apart from providing timber also provide biological products called non-timber forest products (NTFP). Non-Timber Forest Products are other forest materials outside timber which are produced for human use and satisfaction. The Nigerian rural economy is highly dependent on these forest products to generate income and to provide medical care. They've valuable resources that provide a variety of goods and services for millions of people particularly those living in the rural areas in the developing countries including Nigeria. According to Agbogidi and Okonta (2003), a large proportion of urban and rural household depend on the collection or extraction, production and sales of NTFPs to earn their livelihood. According to Ogundele *et al*., (2012), NTFPs are very useful in sustaining livelihood and generate input for secondary production. Studies carried out by Shackleton (2004) showed that extraction, processing, and trading of NTFPs is a common employment opportunity for the teeming population in remote rural areas. Adepoju and Salau (2007) pointed out that NTFPs are a reliable source of income and food supply in the rural areas and several opportunities for improved rural development are allied to NTFPs. The trade-off between environmental quality and economic goods from the forest environment are often overlooked especially when the massive profit from NTFP is considered.

Non-timber forest products according to Centre for International Forest Research, CIFOR (2013) includes forest products such as; nuts, vegetables, fruits, fish, medicinal plants, resins, essences, a range of bark and fibre, bamboo, rattans, honey, insects, animals, fodder, fertilizers, medicinal extracts, construction material, cosmetic and cultural products, natural dyes, latex, tannins, and gums. They also include essential oils, spices, edible oils, mushrooms, horns, tusks, bones, decorative articles, pelts, plumes, hides and skin, non-wood ligno-cellulosic products, phyto-chemical and aroma chemicals. They may be gathered from the wild, or produced in forest plantations, agro forestry schemes and from tree outside forest. More attention is now focused on Non-Timber Forest Products because of the immense benefits they provide for the advancement of man. NTFPs are also described as parts of the plant that have perceived economic or consumption value sufficient to encourage their collection and removal from the forest (Okpachu, *et al.*, (2013).

Non-timber Forest Products (NTFPs) cover a wide range of products with different uniqueness, which are utilized in a variety of context and play significant roles in a range of household livelihood sustenance. This involves thousands of plants, tree and animal species, most of which are consumed within the household of the gatherers and are not traded in markets. Non-Timber Forest Products (NTFPs) have become a topical issue that have attracted global interest in recent times. Forest plays a crucial role in promoting the economic advancement and welfare of the people by its preservative characteristics. Apart from its veritable means of alleviating poverty among rural communities and its livelihood sustenance, forest provides security to the environment (Fisher *et al*. 2010). Removal of timber and other non-timber forest products like food, medicine, aesthetics and other income generation activities for livelihood sustenance by people living around and outside the forest communities is a tragedy to future use of the faming environment. The rate of use or extraction of Non-timber Forest Products is exacting much pressure on the environment as management practices may not economically sustainable. Production of non-timber forest product by agro foresters can sustain the livelihood and the environment but it cannot ascertain economic sustainability when the private benefit of agro foresters exceeds social benefit.

Ehirim (2014), opined that economic viability of farming environment may collapse at the point where economic burden has placed more negative externalities on the environment. According to his studies, such activities removes, some resource stock from the earth surface and replaced it with a heavy volume of waste generated during the process and it builds beyond the carrying capacity of the farming environment with a nuisance value. A technical term used to describe this situation is *externality*. Formally, we define externalities as conditions arising when the actions of some individuals have direct (negative or positive) effects on the welfare or utility of other individuals, none of whom have direct control over that activity. In other words, externalities are incidental benefits (costs) to others for whom they are not specifically intended (Hussen, 2005). Production of NFTPs has been taken for granted for a long time. They have thus been subjected to misuse, overuse and gross undervaluation, and consequently, most NTFPs remain as minor products of the forest. Nigeria and Imo State in particular has a serious issue of market failure from excessive extraction of forest products, which the productive operations of transforming farm inputs into economic goods (NTFPs) has failed sustain. Is it that the replacement of removed NTFPs through productive operations in the forest areas not viable? However, generating the volume of social cost and social benefit from productive operations in NTFPs production is a policy issue and no study has assessed the economic viability of such production in Imo State at least to understand the social benefits that can allow its sustainability in the area. This study wants to address this by investigating the economics of NFTPs production in Imo State.

The rural smallholder economic operators are important stakeholders in natural resource use landscape. In rain crop and livestock production environment, understanding who and how people use, and control forests and farmlands are issues to sustainable agricultural and forest development in Nigeria. Forest and farming environments are common good/property with a third party effect. Its ownership is common to all and any private use is a cost to another. Common property ownership of resources such as the atmosphere has traditionally meant no ownership at all and free access to all users. Environmental degradation of such resources has occurred when the demand has risen to overwhelm their limited capacity to absorb wastes. Individual maximizing behavior becomes perversely inefficient when property rights to resources are held in common and government assertion of public property rights is required to assure efficient resource allocation.

The transformation process involving the activities of productive operators in NTFPs production must create social cost to the environment in form of externalities. Colfer and Pfund (2011) noted that the management of NTFPs in Nigeria does not encourage a viable outcome, because of excessive social cost from negative externalities. Negative externalities can threaten the purity of the forest and natural landscape. Protecting the purity and vitality of the forest and natural landscape is a hard when it has been tempered by the productive operations of transforming material inputs (land, labor, capital and raw materials) into economic goods (NTFPs). There must be inevitable residuals like pollution and environmental degradation. To address this issue, advocating for the use forest environment for the production of NTFPs may be an important condition for preserving the forest but not sufficient enough to sustain such production. FAO (2003) opined that livelihood sustenance of the forest system must ensure a sustainable harvest of NTFPs.

Empirical evidence has shown that concentrating on ecological sustainability at planting and harvesting level is important, but natural regeneration process of NTFPs in the wild is not enough to sustain the pressure exerted on the forest by livelihood activities by the households (Pandey, Triphati and kumar, 2016). The natural environment (forest) has its own self-degrading ability with a million of decomposer population which, given adequate time, will transform the waste (pollution) into harmless material, and/or return it as a nutrient to the ecosystem. In the case of forest environment, extraction and gathering of NTFPs places a burden and replaces the products removed with waste. The forest environment assimilative capacity increases as it rejuvenates by a natural regeneration process. It has a high self degrading ability. The self-degrading capacity of the natural environment is known as *assimilative capacity*. The *quality* of a particular environmental medium (air, water, land and forest) is determined by the extent of its capacity to assimilate (degrade) waste and that depends on the following important factors: First, the assimilative capacity of the environment is *limited*. The forest is not bottomless sink or an infinite repository of waste. This capacity to degrade waste has made the forest and other natural environment a *scarce* resource. Second, the assimilative capacity of the natural environment depends on the flexibility of the ecosystem and the nature of the waste. That is, the natural environment will not degrade any and all waste with equal efficiency. For *degradable* pollutants, such as sewage, food waste, papers, etc., the natural environment can degrade them with relative ease. On the other hand, it is quite ineffective in dealing *with persistent* or *stock* pollutants, such as plastics, glass, most chemicals, and radioactive substances as most of them not bio-degradable.

MATERIALS AND METHODS

The study was carried out in Imo state, Nigeria. The state lies between latitude 14°4' and 8°15'N and longitude 6°4'E. (Onweremadu *et al.,* 2007). The state has 27 local government area and is divided into three Agricultural zones; namely; Okigwe Agricultural zone, which in turn consist of six local government area (LGA's), Owerri Agricultural zones consist of eleven and the remaining ten LGA's are mapped under Orlu Agricultural zone. Imo State has a population of 3,927, 563 with population density of 230 persons per km^2 (NBS, 2009). The area lies within the humid tropical climate, characterized by rain forest vegetation agro-ecology with abundant forest and non-forest resources.

The area has a population of agro-forest prenures with intensified forest, lands and other natural resources operations for livelihood (Ejiogu, 2009). The forest corridor of the state may not be distinctively link, but their features remained the same with rain forest agro-ecology. The productive operations within the forest environment include farming and gathering of non-timber forest products, quarterly maintenance and harvesting of wild palm trees (*Elaeis guineesis*) by the agro forest prenures in the state. While gathering of vegetables like; ukazi (*Gnetum Africanum*), utazi (*Gangronemalatifolium*) and uzuza (*Piper guineense*) and livestock like snails (*Achatinafulica*) appeared very insignificant the production of these different enterprise have dominated the productive economic operations of the agro-forest prenures in the state.

A two-stage sampling technique was used to ensure that the entire State is properly represented in the study. Imo state with the three agricultural zones; Okigwe, Orlu and Owerri zone where used for the study. The rural population of agro-forest prenures were used as the respondents for the study. In the first stage, Local Government Areas (LGA's) known for intensive non-timber forest product operations were purposively selected from the three agricultural zones of the State. They're Ngor-Okpala, Oru East and Onuimo in Owerri, Orlu and Okigwe zone respectively.

In the second stage, a list of agro-forest prenures who were registered with the agricultural department in the selected LGA headquarters was used as sample frame for the study. The list was divided into three (3) set of respondents, which include; the edible oil palm fruit processors, leafy vegetable producers, and snail producers. Due to the unequal number of non-timber forest product producers in the list, the study will use a proportion of 40% of each set of respondent was used to select 55 edible oil palm fruit processors, 38 leafy vegetable and 27 snail farmers respectively in the area using a stratified random sampling technique.

Data were analysed using both descriptive statistical tools (percentages, mean and frequency distribution) and inferential analysis tools. To identify the various social cost and benefits/economic activities associated with different NTFP in the area was analyzed using functional analysis, mean and percentages of the distribution of farmers in the area. To determine the cost and quantity of various inputs and outputs for non-timber forest production in the area was achieved using frequency distribution tables, percentage and mean. To determine the profit and profitability of the selected non-timber forest products in the area was achieved using the cost return model.

Relationship between Net Social Benefit and Net Private Income

The items of social cost (SC) in this study are negative externalities from the productive operations within the forest environment. They are the value of clearing the bush to allow space for planting and replacing leafy vegetables, values of pruned tree branches used as fuel wood/lumbering activities to allow sunrays, value of losses to headers conflicts, shadow values on poaching, wind accidents and breakages and value of ruins to crops and livestock due to erosion and diseases or pest and shadow values on health challenges. Social benefits (SB) must include the benefit derived from the forest environment during productive operations by the agro-forest prenuerus. It include all the values of rejuvenating the forest, forest regeneration and security, value of local fence less its depreciation and value of product used for goodwill and social promotions. 'Internalizing an externality', in the case of an external cost, can be achieved by a government levying taxes equal to the difference between a private cost and a social cost.

Net private benefit is the difference between the total revenue and the total cost productive operation within the forest environment. There is a serious economic consequence on externality when there is a divergence between private and social evaluation of cost and benefit.

Social benefits (SB) = Total Private Benefits (TPB) + External Benefit (ExtB) 1

Social cost (SC) = Total Private Cost (TPC) + External Cost (ExtC) 2

Net income (Π) = Total Private Benefit – Total Private Cost. 3

TPB = SB – ExtB and TPC = SC – ExtC (from equation 1 and 2 above)

Net Income = SB – ExtB – (SC – ExtC)

Therefore, Π = SB – SC + ExtC –ExtB 4

From equation 4, it could be deduced that Π = (SB – ExtB) + (ExtC – SC). Real externality exists when the net social (external) benefit is greater than the net private income (Hussen, 2005). Externality is *positive externality if* net social benefit > Net income and negative otherwise.

The Quantity of Input and Output of NTF Products in Imo State.

The study centres on only red palm oil fruit harvesting, vegetables (ukazi, uziza and utazi) and snail (*AchantinaFulica*). The various inputs and their prices were analysed in a tabular form.

Model Specifications

Cost, Returns and Profitability Index

To determine the profit and profitability of non-timber forest products in the area, will be achieved using the cost return model. The value of sales and costs incurred in harvesting red palm fruits (*Elaeis guineesis*), vegetables such as ukazi (*GnetumAfricanum*), utazi (*Gangronemalatifolium*) and uzuza (*Piper guineense*) and snail (*Achatinafulica*), will be estimated at the current market price. The quantity and unit market price of these various outputs will be used to generate their returns. Hence, the profit of each product will be obtained using the expression:

$II_{i,ii,iii}$ = TPR – TPC

Where; TPR Total private income called total revenue and TPC, measure total private cost from productive operations in the forest environment

II_{i} = Profit (Net income) from edible red palm oil products.

II_{ii} = Profit (Net income) from the aggregate vegetables produced in the area.

II_{iii} = Profit (Net income) from snail products.

RESULTS AND DISCUSSION

Table 1 Socio-economic profile of agro-forest preneurs on NTFPs production in Imo State

The socio-economic profile of the agro-forest prenures is shown in Table 1 below.

Table 1. Socio-Economic profile of Agro-forest prenuers on NTFPs production

Age (years)	Frequency	Percentages (%)
30 – 37	4	5.0
38 – 44	2	2.5
45 – 51	36	45
52 – 58	29	36.3
59 – 65	9	11.3
Total	80 (54 years)	100.00
Gender		
Male	42	52.5
Female	38	47.5
Total	80	100.00
Level of Education		
No Formal	5	6.3
Adult Education	7	8.8
Primary education completed	27	33.8
Secondary education	29	36.0
Tertiary education	12	15.0
Total	80 (12 years)	100.0
Marital Status		

Married	67	83.8
Single	1	1.2
Widowed	12	15.0
Total	80	100.00
Years of Experience (years)		
1 – 10	54	67.5
11 – 20	25	31.3
21 – 30	1	1.3
Total (Mean)	80 (8 years)	100.00
Household size		
1 – 3	8	10.0
4 – 6	43	53.8
7 - 9	29	36.3
Total (Mean)	80 (5 persons/House	100.00
Farm Size (ha)		
0.1 – 2.5	64	80.0
2.6 – 5.0	12	15.0
➢ **5.1**	4	5.0
Total	80	100.0
Mean	1.92ha	

Source: Field Survey 2023

The result shows that 36.3% of the NTFP agro-forest prenures were in the age category of 52 – 58 years, 11.3% of them were in the age category of 59-65 years, 4.5% of them were in the age category of 38 – 44 years while only 5% of them were in the age category of 30 – 37 years. The mean age in the study area was 54 years. This is an indication that NTFP agro-forest prenuers are gradually ageing. The ageing population in forestry management and productive operations may imply that productivity may drop if nothing is done to raise youth's appetite in forestry activities of the state. There is a sharp contrast with Fakayode et. al. (2008); Larinde and Santus (2014) observations who reported that majority of agriprenures are mostly young and within their productive age. Agro-forest prenures on NTFP production were mostly males (52.5%) and 47.5% of them were females indicating that NTFP productive operations are male dominated giving the intensive physical labour requirement involved in the operation.

The result further reveals that 53.8% of the NTFP agri-forest prenuers had between 4 – 6 persons in their households; about 36.3% of them had 7 – 9 persons in their households while only 10% of them had 1 – 3 persons in their households. The mean household size was 5 persons per household, which implies that the agri-forest prenures could probably have reasonable farm hands that could help in NFTP productions. There is a positive side to this finding. The intensive labour demand of NTFP production in the state can be sourced within the household, thus reducing cost of hiring labour for their operations. This finding is consistent with Larinde and Santus (2014) as well as Mujawamariya and karimov (2014) both observed that large household size could be an advantage in the farm operations to reduce cost of hiring labour. Again, majority (36.0%) of agro-forest prenures on NTFP production has completed secondary education and 15% of them have attained tertiary education. It could be deduced from this finding that agri-forest prenures have acquired enough formal education and skills for a productive NTFP production. This evidence conforms to earlier results of Mujawamariya and karimov (2014) and Newton et al. (2016) that observed that education attainment enhances the ability of agro-forest operations.

NTFP agro-prenures were mostly (83.8%) married, 15% of them were widowed and only 1.2% of them were single. NTFP productive operation is dominated by married people and a commitment for family upkeeps and responsibility can engender rational productive activities by the people. It could also be seen from the result that 67.5% of the NTFP agro-forest prenuers had between 1 – 10 years of experience, about 31.3% of them had between 11 - 20 years of experience and only 1.3% of them had 21 – 30 years of experience. The mean year of experience was 8 years. This indicated that most NTFP agro-forest prenures are well experienced and knowledgeable in the business as shown by their years of engagement in the productive operation. This will enhance their performance in terms of improved production and marketing techniques to ensure profitability of their enterprise. Ehirim, Onyeagocha, Ben-Chendo, Essien, Osuji and Okwara (2016) argued that more experienced farmer could predict the future outcome of production with some probability by considering performance of past years.

Table 2 Private Cost and Benefits of NFTP Productive Operations in Imo State

Private net returns of leafy vegetable production in the state

The cost and returns analysis for leafy vegetables per hectare of forest farmland in Imo State is contained in Table 2.

Table 2. Cost and Returns for Leafy Vegetables produced

Variables Private Revenue	Detail Description	Amount/*ha*	%
Ukazi (*Gnetum africanum)*	89.5kg of *Gnetum africanum* @ N203.00/kg	18,168.50	69.9
Utazi (*Gangronem alatifolium*)	122kg of *Gangronem alatifolium* @N117.23/kg	14,302.06	55.0
Uziza (Piper guineense)	126.9kg of *Piper guineense* @ N103.43/kg	13,125.27	50.5
A. Total private revenue	-	45,595.83	175.5
Private Cost	-		
Labour	5 man-days @ N1814/man-day	9,207.00	35.4
Cost of planting materials	-	3,686.04	14.2
Cost of fertilizer	-	6,681.60	25.7
B. VARIABLE COST		19,574.64	75.3
Rent on farmland	-	5,500.00	21.2
Depreciation on fixed assets	-	907.00	3.5
C. Fixed cost	-	6,407.00	24
D. Total private cost	-	25,981.64	100.0
Gross Margin (A - B) = E	-	26,021.19	100.2
Net Returns (E - C) OR (A - D) = F	-	19,614.19	75.5
Return to capital (A / D)	-	1.755	

Source: Field Survey 2023

The gross margin, which is estimated as total private income (revenue) less total private variable cost of the operations, which is ₦26,021.49/ha. The proportion of total leafy vegetables, like ukazi; (*Gnetum africanum*), utazi (*Gangronem alatifolium*) and uzuza (*Piper guineense*) produced and sold (revenue) actually dominated the private variable cost of production of ₦25,981.64/ha by 100.2% implying that for every ₦1.00 private variable cost of operation can quickly be recouped the immediate input requirement of productive operation with an additional ₦1.02 per hectare in the forest environment. The immediate returns from the productive operations within the forest environment is as high as 100.2% of the total private cost, suggesting that the possible external cost is less than external benefit to allow the forest environment produce such high immediate returns. In the same way, the net returns of ₦19,614.19/ha resulting to a rate of returns to capital invested in the productive operations within the forest environment of 1.76/ha. There is about ₦0.76 returns per hectare from every ₦1.00 total private cost per hectare in the forest environment. This finding supports the observation of Tekwe, Ndam and Nkefor (2003) that G. africanum produced within agro-forest environment will enhance trade and sustain the livelihood giving the increasing returns to capital invested.

The positive net private returns can exist in future if the net social benefit is continually positive. The possible external benefit from the forest environment can allow a positive transformation of inputs to generate an additional of ₦19,614.19/ha from leafy vegetable in the area. This may not continue in the very long run if there is any external cost due to the productive operation in the forest environment. The effect on the future productive operation in forest environment is dependent on the nature of net social benefit. Since the private net return is positive, there is the possibility that the positive private net revenue is drawn from other positive social benefit contributed by the operations outside their immediate forest environment.

Table 3 The Net Returns from Oil Palm Fruit Harvesting

Table 3 presents the result of net returns on oil palm fruit harvesting within the forest environment in the state.

Table 3. Cost and Returns on Palm Fruit Harvesting

Variables Private Revenue	Detail Description	Amount/ farmer	%
Sales of red palm oil fruits (*Elaeis guineesis*)	652.2kg of *Elaeis guineesis* @ ₦903.00/kg	485,674.44	149.6
Sales of palm fronds and shelled bunches	-	10,334.56	3.2
A. Total private revenue	**-**	**498,009.00**	153.4
Private Cost	-		

Labour	133 man-days @ N1252.12/man-day	166,532.00	51.3
Haulage and Transportation	652.2kg of *Elaeis guineesis* @ ₦75.79	49,432.98	15.2
Pruning and harvesting cost	-	54,904.01	16.9
Cost of maintaining the palm stand	-	13,994.66	4.3
B. Variable Cost	-	**284,863.65**	87.8
Rent on palm stands	-	18,429.00	5.7
Depreciation on fixed assets	-	21,290.30	6.6
C. Fixed cost	-	**39,719.30**	12.2
D. Total private cost	-	**324,582.95**	100.0
Gross Margin (A - B) = E	-	**213,145.35**	65.7
Net Returns (E - C) OR (A - D) = F	-	**173,476.05**	53.4
Return to capital (A / D)	-	**0.5344 53.44%**	

Source: Field survey 2023

The total private cost of harvesting oil palm fruit harvesting in the state N324,582.95 per farmer. The private variable cost is about 87.8% of the private total cost while the fixed cost dominated only 12.2% of the total private cost in oil palm fruit harvesting in the area. Cost of labour (51.3%) dominated the greater part of the private variable cost followed by pruning and harvesting cost per farmer. Oil palm fruit harvesting is very labourous and can only be taken by young energetic men in the area. This finding is not consistent with Eforuoku (2016) observation that Nigerian farming population is ageing and the ageing population is becoming practically impossible to deliver the expected productivity that will meet the need of the growing population. Again with the growing labour crunch in oil palm production and management in the forest environment may be the reason for the high cost of labour. Alabi et al. (2020) identified that harvesting among other productive operations in oil palm management within the forest environment is manually done with only traditional or semi-skilled mechanized methods, which is very labour intensive.
The findings of the study showed that total private revenue of ₦498,009.00 is generated from sales of harvested oil palm fruits per agro-forest prenuer. The gross margin was however, estimated to be ₦213,145.35 and the net returns were further estimated as ₦173,476.05 per farmer in the state. The gross and net private margins are 0.657 and 0.534% respectively to the total cost. This implies that a rate of return to operating expenses and total capital invested of 65.7% and 53.4% respectively were presented. For every ₦1 spent on operating expense in oil palm tree maintenance and harvesting of oil palm fruits within the forest environment will give an additional ₦0.65 per agro-forest prenuers while ₦0.53 will be generated from ever ₦1.00 capital invested in the state.

Table 4 Net Private Benefit in Snail Production

The gross margin analysis of snail production within the forest environment of the state is shown in Table 4

Table 4: Cost and Returns for Snail production in the State

Variables	Detail Description	Amount ₦/farmer	%
Private Revenue			
Sales of table size snails	978 pieces of table size snail @ ₦152.04/each	148,695.12	183.8
Sales of breeding stock	205 pieces of breeding stock @ ₦200.00 each	41,000.00	50.7
A. Total private revenue	-	**189,695.12**	234.5
Private Cost	-		
Labour	23 man-days @ ₦1500.00/man-day	34,500.00	42.7
Haulage and transportation	-	12,701.77	15.7
Feeds, concentrates and drugs	-	8,448.00	10.4
Juvenile stock	120 pieces of juvenile stock @ ₦100.00 each	12,000.00	14.8
B. Variable Cost	-	**67,649.77**	83.6
Rent	-	12,000.00	14.8

Depreciation on fixed assets	-	1,229.89	1.52
C. Fixed cost	-	**13,229.89**	16.4
D. Total private cost	-	**80,879.66**	100.0
Gross Margin (A - B) = E	-	**122045.35**	150.9
Net Returns (E - C) OR (A - D) = F	-	**108815.46**	134.5
Return to capital (A / D)	-	**1.35 134.5%**	

Source: Field Survey 2023

The total private return is ₦189, 695.12 per farmer in the area and there is a better improvement in production in the state with a return to capital of 134.5%. There is a more than proportionate increase in return to capital invested of 1.35 in the state. This implies that there is a more than ₦1.35 returns from every ₦1.00 spent in snail production within the forest environment in the state. The reason for this high rate of returns to capital can be explained by the low cost implication of the enterprise in the state. The total private cost of production is ₦80, 879.66 with total variable cost of ₦67, 649.77 recording of about 83.7% of the total private cost dominating the capital investment of the enterprise in the state. Although labour cost (42.7%) is higher than other input requirement in snail production, labour demand is relatively lower compare to other productive operation within the forest environment.

Table 5 Social Cost and Social Benefits of NTFP Productive Operation in Imo State.

The result in Table 5 presents the estimated social cost and social benefit arising due to externalities from productive operations within the forest environment in the state.

Table 5. Social Cost and Benefits of NTFP from Productive Operations in Forest Environment of the State

Variables	**Detail Descriptions**	**Amount (₦)/*ha***
Social Cost		
Value of bush clearing by burning.	Value of clearing the bush to allow space for planting and replacing leafy vegetables.	6,000.00
Pruning/ lumbering, deforestation, cattle headers and conflict	Values of pruned branches for fuel/lumbering activities to allow sunrays. Headers conflicts	93,100.00
Amount spent on erosion control, drainages and poaching	Shadow values to poaching, wind brakes and erosion, crop failure to disease and pest, health	57,000.00
Total		156,100.00
Social Benefits		
Value for forest guards and patrol team	Value of product saved by the patrol team	10,000.00
Value of local fences within forest, tree planting, mulching & soil amendments	Dep. of local fence, manuring, afforestation, erosion control, drainages and irrigation	28,000.00
Value of product shared with people	Value of social promotion and goodwill	53,000.00
Total		91,000.00
Net Social Benefit (NSB)		- 65,100.00
External Cost		
Value of crop destroyed by flooding		
External Benefit		
Value of		

Source: Field Survey 2023

The total social cost of ₦156,100.00 from all the productive operation within the forest environment in the state was higher than the social benefit derived from the forest environment, which is ₦91,000.00 in the state. Negative net social benefit (₦65, 100.00) may generally be due to increasing external cost within the forest environment. The forest environment naturally provides enough social benefits for a sustainable NTFP productive operation. The advantages provided by the forest environment and the high negative externalities due to productive operations are at the crossroads. The private productive operators within the forest environment have recorded more net benefit and that has an additive impact on the degenerative development of the forest environment and sustainable NTFP production becomes elusive. The use the forest for NTFP production is difficult to *exclude other social benefits it has generated or derived from the outside the immediate private operations in the state*.

Forest resource is a common property and by its very nature, has a *non-rival* consumption implication, and hence, subject to *joint consumption*. 'Internalizing an externality,' in this case, due to the external cost from productive operations of NTFP production, can be achieved by a government levying taxes at least less or equal to net private benefit. The taxes and levies will be used to provide other social benefits that builds more external benefit within the forest environment in the state. Alternatively, the private agro-forest industry can build a wedge (internalizing) between extreme externalities using part of their net private benefit as *transaction cost*. Again, when the *transaction cost* of internalizing the externality is excessively high that the private operators within the forest environment cannot meet up with the extreme social cost, giving part of their returns to the environment inform of tax or levies to government may ensure sustainability (Hussen, 2005).

In a similar manner, NTFP productive operations enjoyed a non-exclusive property right of the forest environment in the state to attain a high net private benefit. The stakeholders in NTFP production are not excluded from the positive externalities within the forest environment. Their positive net private returns, which drew strength from the external benefit of forest environment, may've extended production capacity of the operators in the long run. The inclusive impact of external benefits, apparently from net social benefit of other forest users or the regenerative capacity of the forest resources in the state may've enhanced this sustainable NTFP production. The non-exclusive property of forest environment in the state extended its sustainable production of NTFP in the state. If the forest environment had an exclusive property implication, the productive operation may shut down and cannot operate even when they have met with all their fixed input in the near future giving the negative net social benefit from private operators in NTFP production in the state.

CONCLUSION AND RECOMMENDATIONS

The forest resources as a common property with non-rivalry consumption implication and non-exclusive property provide the forest environment can attract more external cost giving the adverse operations of agro-forest prenuers. NTFP productive operations in the state may not continue in the future despite their net private gains. Sustainable NTFP production cannot continue in the future without cushioning the effect extreme negative externalities of productive operations in the forest. The difference between the positive net private gains from NTFP productive operations and the negative net social benefit derived from the forest suggest that there is an increasing external cost from the productive operation within the forest environment. There sustainability of NTFP production in the state can only be achieved if the productive operations within the forest environment enhance its external benefit. The study therefore recommends the following:

i. Encouraging the youths in NTFP productive operations will not only provide employment opportunities to the youths but also reduce the cost of labour to increase net private profit within the forest environment in the state.
ii. Agro-forest prenures should intensify more wedges (transactional cost) against negative externalities in all the productive operations. This will increase the social benefit, reduce external cost and improve external benefits of the forest areas.
iii. Government policies should move towards encouraging farmers to pay levies and environmental tax to help internalize externalities coming from the productive operations within the forest environment in the state.

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TREE SPECIES DIVERSITY INDEX AS A TOOL FOR ECOLOGICAL AND BIODIVERSITY ASSESSMENT: A REVIEW

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ABSTRACT
The significance of biodiversity research is to understand the structure and function of an ecosystem or community, and then to protect and monitor their biodiversity. Thus, this study reviewed the tree species diversity index (species richness, dominance, evenness etc.) as a management tool that can be used to assess the ecological variables present in an ecosystem. The role of species diversity index in biodiversity and ecological assessment was also highlighted.
Keywords: *Biodiversity conservation, ecosystem, richness, species diversity*

INTRODUCTION
The structure and tree composition of forest is a vital instrument for forest managers in assessing the sustainability of the forest, species conservation, and management of forest ecosystems (Zhao et al., 2022). The relationship between biodiversity and ecosystem functioning and productivity has received increasing attention within the scientific community recently (McNaughton, 1994; Hooper et al., 2005). However, many of these biodiversity in the tropical forests are under great anthropogenic pressure and require management interventions to maintain the overall biodiversity, productivity, and sustainability (Kumar et al., 2006). Biodiversity research has therefore developed to become an important part of functional ecology and conservation biology (Ma, 2016).
Tropical forests are the subject of several studies to better understand the role they could play in sustainable development, climate change, and floristic biodiversity (Djuikouo et al., 2010). Globally, 52% of the total forests are in tropical regions and they are known to be the most important areas in terms of biodiversity (Djuikouo et al., 2010). This diversity is an indicator that allows appreciating links between the richness and the abundance of individuals' trees; it reflects the degree of heterogeneity or stability of vegetation (Ifo et al., 2016). It is widely accepted that biodiversity can be divided into three spheres: genetic diversity (within-species diversity), ecosystem diversity (diversity of communities) and species diversity (number of species). It is important to understand that biodiversity has a broader meaning than species diversity because it includes both genetic diversity and ecosystem diversity. Nevertheless species diversity is a large part of the focus of biodiversity at the local and regional scale. However, for this review, the focus will be on species diversity.

1. Genetic diversity (within-species diversity)
   This refers to the range of different inherited traits within a species. In a species with high genetic diversity, there would be many individuals with a wide variety of different traits. Genetic diversity is critical for population to adapt to changing environments. The primary sources of genetic diversity are mutation, genetic recombination and gene flow in the population.
2. Ecosystem diversity (diversity of communities)
   Ecosystem diversity describes the number of niches, trophic levels and various ecological processes that sustain energy flow, food webs and the recycling of nutrients. Three indices or varieties of ecosystem diversity or community diversity are Alpha diversity, Beta diversity and Gamma diversity.
3. Species diversity (Number of species)

This is the number of different species present in an ecosystem and relative abundance of each of those species. A quantitative assessment of species diversity is very important for effective biodiversity conservation and management (Magurran, 2004).

Over the years, trees have undergone different levels of disturbance due to unprecedented increase in human population, which have led to cutting of trees for firewood collection, charcoal production, and infrastructural developments (Kacholi et al. 2019). However, in order to protect the trees from declining, it is essential to examine the status of species diversity, composition, and abundance as it will provide guidance for their management and valuable reference for assessment as well as improve the knowledge in identification of ecologically useful species (Kacholi et al., 2019). Also, for the protection and sustainability of forest ecosystems, development of management plans focusing on the dynamics and biodiversity of these ecosystems can only be possible if the processes of the ecosystems are learned, and the information collected is institutionalized.

Measures of biodiversity

Various indices have been proposed to capture information about the diversity of a plant community (Margalef, 1958; Magurran, 2004; Hui et al., 2011; Chao et al., 2013). The principal objective of a diversity index is to obtain a quantitative estimate of biological variability that can be used to compare biological entities in space or time. Species diversity indices can be divided into two components: species richness and species evenness. Species richness represents the total number of species within a given area, while species evenness measures how similar species are in their abundances (Hurlbert, 1971; Magurran, 2004). These two diversity components may vary independently and could be influenced by different ecological processes.

The biodiversity of an ecosystem often depends on multiple measurements. While these measurements are often confused, they all represent individual values that are non-synonymous. The most confused measurements of an ecosystem include:

- Species richness
- Species abundance
- Species diversity
- Species evenness
- Species dominance

Species richness

This is the simplest measure of species diversity and is either a count of the number, or the list of species inhabiting a given area or habitat. Measures of species diversity are formed from species richness by further classification to other attributes such as abundance, size or ecological role. Species richness is the value derived when the number of species in an area is estimated either by direct counting or using evaluating index. This is a good measure of biodiversity because it directly measures the biologic difference between organisms that coexist in a given biome. It explains the ecological resilience and degree biologic homogeneity of a given region.

With high species richness, food chains and energy pyramids become more active and productive, as organisms form complex inter-species relationships that enable them adapt and thrive under various environmental circumstances. Example of index to use for assessing richness are Menhinick and Margalef's index.

Menhinick index (dm): This is a particular measure of species richness. Species richness is a measure of the number of species found in a sample. It is calculated thus:

$D_m = \frac{S}{\sqrt{N}}$………………………………………. Equation 1

Margalef's index (d): This is used to calculate the species richness. It is based on the relationship between total number of species (S) and total number of individuals (N). It is given as follows:

(d) = $\frac{S-1}{Ln(N)}$……………………………....Equation 2

Where S is the total number of species; N is the total number of individuals and Ln is the natural logarithm, dm is the *Menhinick index,* d is the Margalef's index

Species abundance

This is the total number of individuals that make up each species within an ecosystem. It is often mistaken with species richness. For example a forest that has deer, trees, and snails. The species abundance of this forest may report that there are 15 deer, 10 trees, and 45 snails. The species richness of this forest, however, would be reported as 3 species. Thus, species abundance versus richness portrays different ecosystem values.

Species diversity

This is another measurement to understand the biodiversity within an ecosystem. Where abundance is the number of individuals and richness is the number of species, species diversity considers both. Species diversity is usually calculated and compared to a scale or index. Thus, the reported value is a single value that attempts to categorize ecosystems so that they may be compared and does not represent a counted value. Example of index to examine the species diversity of a community is the Shannon-Weiner index.

Shannon-Wiener Diversity Index (H'): This is a useful index in community ecology assessment. The index standardizes the percentage abundance of species in a proportionate way (Turkis and Elma, 2018) and expresses the proportion of the coverage of a given species in the total sample. The negative multiplication value of the summation of the "ln" values of all species multiplied with their own numbers yield the Shannon-wiener value (Zhang 2004; Turkis and Elma, 2018). It is given by:

$H' = -\sum_{i=1}^{S} PiLnPi$ ....Equation 3

Where: H' is the Shannon-Wiener diversity index; S is the total number of species in the community; pi is the proportion of *S* made up of the *i*th species; Ln is natural logarithm.

Species evenness

This is a measure of how evenly spread a species is within a community. Species evenness applies to all three above defined measurements when scale is applied. When a species is evenly spread across sites, its abundances and contribution to richness appears similar from site to site. When a species is not evenly distributed across sites, it may or may not contribute to a particular sites diversity and may contribute to high numbers, or not at all, to richness depending on if pockets of organisms are found. Because both richness and abundance contribute to diversity and evenness can affect both, evenness also impacts diversity. Example of index to examine the species eveness of a community is the Pielous evenness index.

Pielou's Species Evenness Index (E'): The ratio of the observed diversity (H) to the maximum diversity (Hmax) is taken as a measure of evenness (E).

$E' = \frac{\sum_{i=1}^{S} PiLnPi}{Ln(S)}$ ……………………………………….Equation 4

Where, S is the total number of species. E is constrained between 0 and 1.0 with 1.0 representing a situation in which all species are equally abundant.

Tree species dominance

Tree species dominance calculated by using Simpson's dominance index (D). It is represented as

D = Σ (ni * (ni – 1)/(N *(N – 1)……….. ……………....Equation 5

Where ni – Number of individuals in the ith species and N – the total number of individuals

The reciprocal (*D*) of Simpson's index (number of very abundant species) will ensure that the index *D* increases with increasing diversity.

Roles of species diversity indices in biodiversity and ecological assessments

Kacholi et al. (2019) stated the followings:

i. A better understanding of the mechanisms that contribute to species diversity will allow for a better predict and management of future biodiversity
ii. Provide important information about rarity and commonness of species in a community.
iii. It provides information on the stability and sustainability of the forest communities (Sakar and Devi 2014).
iv. Information obtained from studies on forest species richness and diversity is a very important component in management in terms of economic value, regeneration potential and for biodiversity conservation value

CONCLUSION

Regular assessment the biodiversity and forest ecosystems using standard ecological index tools will go a long way to assist ecologists and forest conservationists for a better understanding of operating dynamics in their ecosystem to ensure sustainable management of the resources therein.

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CONSTRAINTS OF BEEKEEPING IN THE TROPICAL RAINFOREST AND GUINEA SAVANNAH VEGETATION ZONE OF OYO STATE, NIGERIA

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ABSTRACT
The study was conducted to examine the challenges faced by beekeepers in the major beekeeping locations in Oyo state. Informed questionnaire was administered to 82 and 89 respondent beekeepers in Ibadan and Saki respectively with a target to reach at least 70% of the total number of beekeepers in the study areas. Location, sex and age distribution of beekeepers were recorded, also the anthropogenic activities affecting beekeeping was ranked alongside with management practices of pest of honeybees in the study areas. Descriptive statistics such as percentages, bar chat and frequency were used to analyze the data obtained. The result showed that the larger percentage of beekeepers were 85.4% male while 14.6% were female. Also, the survey revealed that larger number of beekeepers in the study area are youths and are between the ages of 18 and 40. Theft was the most serious constrain of beekeeping in the study area followed by herders issue, bush burning and uncontrolled use of pesticides. The most effective means of preventing bush burning as reported by beekeepers was 77.77% fire tracing followed by positioning beehives on tall trees and weeding at 7%. The use of spent engine oil at the base of hive stands was the most ranked by respondents with 48.53%, and avoidance of scattering harvested honeycomb and removal of dirt in the apiary and the least ranked were smoking of hives and spreading of wood ash as local insect repellant. 57.3% of the beekeepers were of the opinion that hiring security guards is the most effective means of protecting hive from thieves and herders also, 30.4% were of the opinion that fencing of apiary will serve as the most effective means of securing hives and 12.28% supported the use of bee pen. It was concluded that If the constrains of beekeeping in the study area is curbed 100% of beekeepers were ready to go into beekeeping at a commercial scale.
Keywords: *Anthropogenic, beekeeping, fire tracing, honeycomb, beehive.*

INTRODUCTION
In Nigeria, beekeeping has been part of the existing traditional agricultural venture of Oke ogun people in Oyo and the Tivs in Benue States but despite the long term of beekeeping practice in those locations honey production has always been insufficient and never satisfied local demand not to talk of exportation (Akinwande *et al.*, 2013). The lucrativeness of beekeeping to the society is unique as the enterprise is a means of empowering people economically because of its numerous advantages over other types of agricultural enterprises, Beekeeping doesn't require owning a land and the fertility of the soil has nothing to do the productivity of the enterprise because hives are either placed on the trees or on the ground (Lawal *et al*., 2020).
Despite the known defensive mechanism of honeybees there are serious problems in honeybee production, ranging from hive that houses the bees to hive produce and insect pest infestation, anthropogenic activities and incessant use of pesticides and many more (Shu'aib *et al*., 2009; Oyerinde and Ande, 2009; Lawal *et al*., 2021).

METHODOLOGY
Mixed methods such as key informant interviews and observations were utilized for data collection so as to capture all relevant information. A total number of 171 copies of the questionnaire were administered purposively to members of the Federation of Beekeepers Association of Nigeria (FEBKAN). The leadership of the association in the study areas (Saki and Ibadan) served as facilitators towards getting 82 and 89 respondent beekeepers from the two purposively selected locations. The administered number was targeted to meet up with at least 70% of the total population of beekeepers in Ibadan and Saki respectively, the study locations were chosen based on the fact that Ibadan

and Saki are known for beekeeping with numerous numbers of beekeepers and established apiaries. The data retrieved after administering the questionnaire included: demographic features of beekeepers, human activities causing problem to beekeeping and methods used in solving problems encountered. The survey was conducted between January to October 2021. Data collected were subjected to different procedures such as descriptive statistics for demographic features of beekeepers while bar chart and pie chat was used to show the frequency distribution.

RESULTS AND DISCUSSION

The demographic features of the respondents were assessed under location, sex and age distribution. The respondent beekeepers from Saki West, East and Atisbo Local Government of Oke, Ogun State were 89 in number equivalent to 52% while the informed questionnaire was administered to 82 (48%) to apiary farmers in Ibadan (Table 1). Beekeepers in Ibadan and its environs had larger percentages of beekeepers which were male (85.4%) while 14.6% were female reflecting male dominance in beekeeping sector. This can be traced back to honey hunting known to be origin of ancient beekeeping majorly engaged by men (hunters). It involved tedious work of tree climbing, encountering bee stings and moving inside thick forest which is naturally undesirable for women. This could be ascribed to earlier reports by (Olana and Demrew, 2018) that women participation in beekeeping was low compared to men. This survey revealed that larger number of beekeepers in the study area were youths between the ages of 18 and 40 showing that they could actively participate in beekeeping activities ranging from hive making, installation, baiting, harvesting and other rigorous unforeseen challenges that might occur in the apiary compared to older people. This corroborates the findings of Oluwatosin (2008) who reported the age range of beekeepers to be between 31 – 40 years and 31 – 35years at Ekiti and Borno State, respectively.

Table 1: Location, sex and age distribution of respondent beekeepers

Variable		
LOCATION	**RESPONDENT**	**%**
Saki	89	52
Ibadan	82	48
TOTAL	171	100
SEX		
Male	146	85.4
Female	25	14.6
TOTAL	171	100
AGE		
18 – 40	88	51.5
41-70	73	42.7
71ABOVE	10	5.8
TOTAL	171	100

Beekeepers in the study locations were asked to rank some of the crucial challenges associated with beekeeping in the area in the order of their importance. The results of the survey are presented in (Table 2) which shows that 100% of the respondent beekeepers indicated that theft was the most serious constraints and could be attributed to local hunters that sets beehives on fire or use insecticide on bees and kill them then go away with honey thereby leaving main hives and top-bars burnt. Other constraints included human activity such as herders (53.8%) where cattle invade hives thereby leading to beekeepers/herders clash. The third ranked factor was bush burning with 36.25% and lastly incessant use of pesticide 20.46% leading to mortality of bees. This concurs with earlier report by (Tijani *et al*., 2011) that the major problems of beekeeping were theft, inadequate credit to purchase inputs for beekeeping, absconding of bees and inadequate improved technologies.

Table 2: Anthropogenic activities affecting beekeeping in Oyo State

S/N	Activities	Rank	Frequency	Percentage
1	Theft	1	171	100
2	Herdsmen	2	92	53.8
3	Bush burning	3	62	36.25
4	Pesticidal use	4	35	20.46

The management techniques used in curbing the menace of bush burning as a serious issue in beekeeping productivity were ranked and the following frequencies and percentages were recorded. The most effective means of preventing bush burning as reported by beekeepers was fire tracing 77.77% (Figure 1) followed by positioning beehives on tall trees, weeding at 7% and cleaning of the apiary.

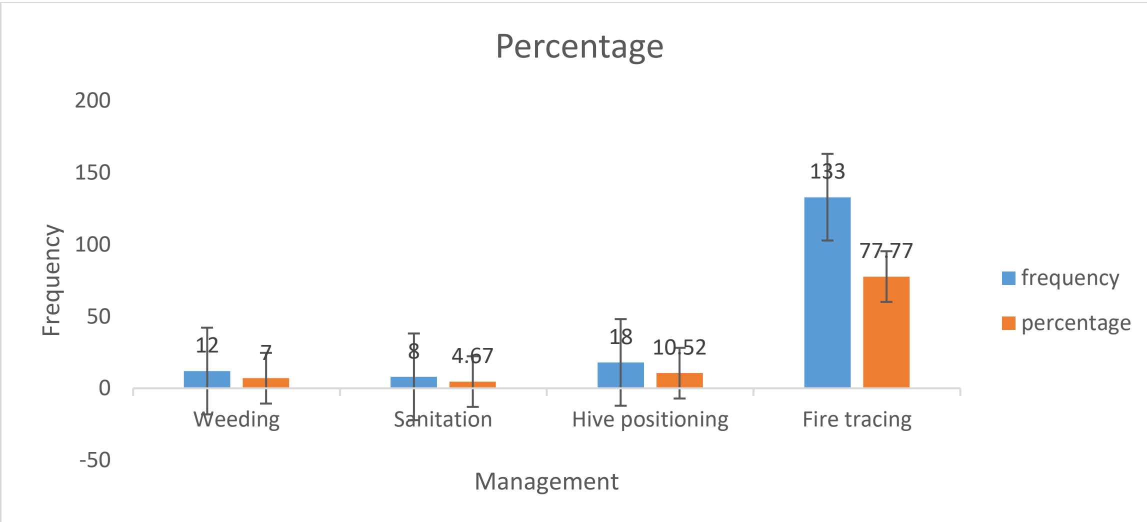

Figure 1: Management techniques in curbing the menace of bush burning in beekeeping

There are eco-friendly management practices that are known to be effective in the management of insect pest of honeybees, the use of spent engine oil at the base of hive stands was the most ranked by respondents (48.53%) (Figure 2) and avoidance of scattering harvested honeycomb followed by removal of dirt in the apiary so as to reduce the possibility of carrying insect pest developmental stages that can be easily transferred from one hive to the other and burning and/or burying the said materials at a faraway place in order to reduce pest load in the apiary while the least ranked management practices were smoking and the use of ash in the control of insect pest. This was in line with the report of (Rachna, 2004).

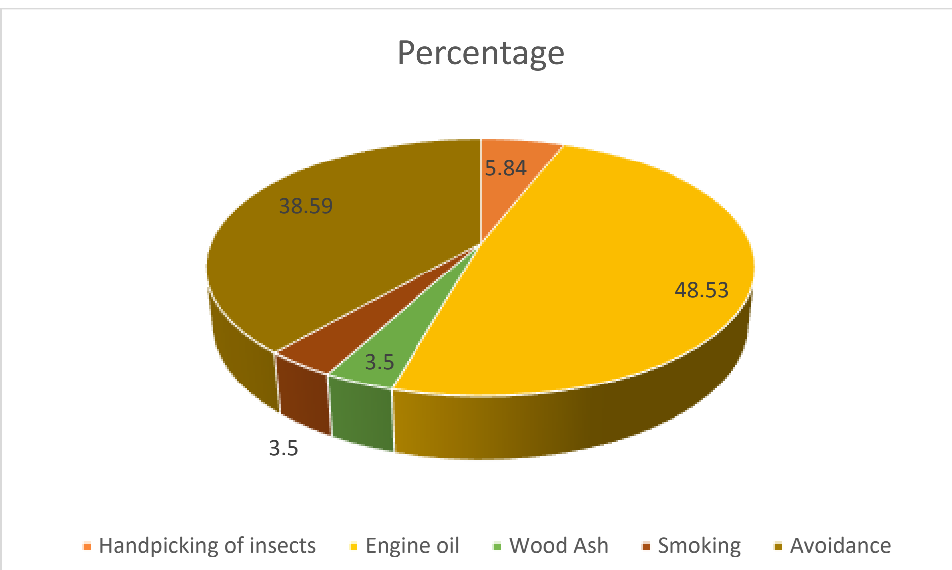

Figure 2: Pest management techniques in beekeeping

Three management practices were ranked by respondent beekeepers in the study areas, the dominant percentage of 57.3% (Figure 3) were of the opinion that hiring security guards will bring a lasting solution to the challenges caused by herders and stealing of hive resources while 30.4% were of the opinion that fencing of apiary will serve as the most effective means of securing hives and 12.28% supported the use of bee pen. This conforms with (Famuyide *et al.*,

2014) who reported that beekeeping was seriously affected by stealing and vandalization of beehives in Oyo state and the need to provide a lasting solution to such menace will increase the production capacity of apiaries.

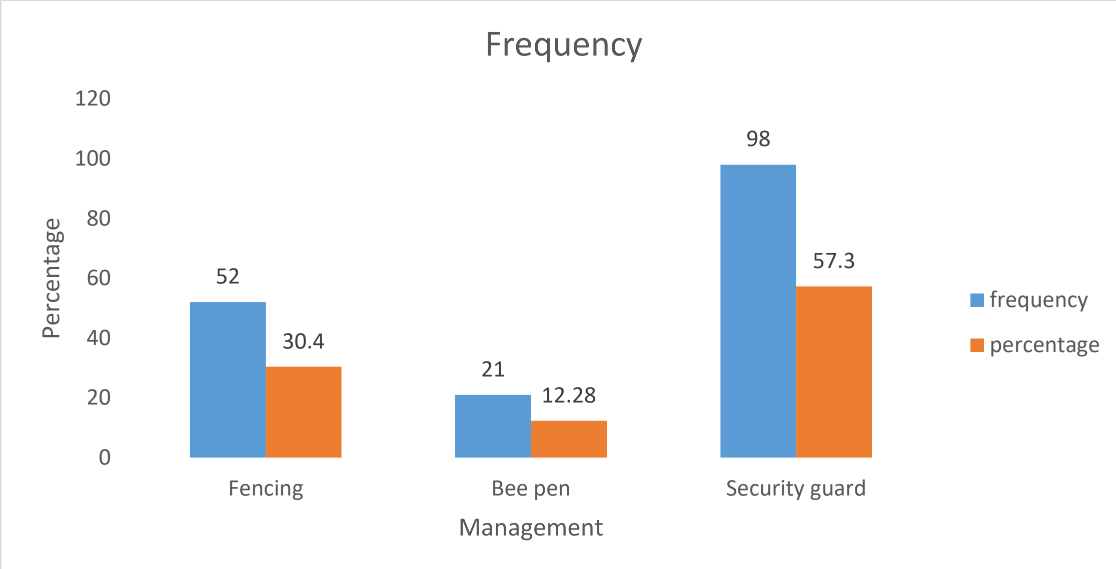

Figure 3: Percentage and frequency of management practices used in curbing theft and herders problem

CONCLUSION

The study concluded from the findings from the respondent that beekeepers are ready to go into beekeeping at a commercial scale if the major constrains of beekeeping are adequately curbed.

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EFFECT OF BEEKEEPING ON THE LIVELIHOOD OF BEE FARMERS IN ABIA STATE, NIGERIA

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ABSTRACT
The study examined the effect of beekeeping on the livelihood of bee farmers in Abia State, Nigeria. A multi stage sampling technique was used in selecting 120 bee farmers for the study. Data collected was analyzed using descriptive and inferential statistics such as frequency count, percentages, mean and t-test. The result revealed that 51.67% of the bee farmers have acquired tertiary education. About 55.00% of the bee farmers had farming experience of 11-20 years. Majority of the respondents (75.97%) are part-time bee farmers. The result on the income showed that 45.00% of the bee farmers had annual income that fell between ₦300,000 - 400,000. The mean income of bee farmers before and after utilization of improved honey production technology was ₦222.666.7 and ₦377.333.3. The result shows that improved honey bee production technology has increased the farmers output and income, thus improving their livelihood and economic status.

INTRODUCTION
Livelihood of communities living in rural areas is typically dependent on subsistence agriculture and smallholder farming. The needs of smallholder rural farmers for livelihoods cannot be addressed without providing them alternative source of income within available resources. Beekeeping has been identified generally as one of the most lucrative enterprise and an alternative livelihood option with potential of providing alternative income security to smallholder farmers living in rural areas. Previous studies indicates that the beekeeping activity provide benefits in terms of employment, pollination of crops and conservation of biodiversity (Uchechukwu *et al.,* 2020). It also generates income through hive products. It is a liable key in reducing poverty and starvation through job creation particularly for the unemployed youths and poor rural populace. The products of bees are source of income and have the potentials to enhance livelihood opportunities for small scale bee farmers. Honey is highly nutritious, has medicinal values and can be used to make products that can generate income for farmers who might lose crops due to inconsistent rainfall or drought. Uchechukwu et al. (2020) reported that food, pharmaceutical, cosmetic as well as brewery industries depend on honey as part of their raw materials in the production of their commodities. There is inadequate information on use of bee honey, technology and income of bee farmer in the study area. Hence, the study aimed to assess the effect of beekeeping on the livelihood of bee farmers in Abia state, Nigeria.

METHODOLOGY
The study was conducted in Abia state. A multi stage sampling technique was used to collect data for the study. In the first stage, the three Agricultural zone of the state namely Aba, Umuahia and Ohafia Zone were involved. Secondly, two blocks were randomly selected from each of the zone, making it twelve circles. Finally, ten bee farmers were randomly selected from the circles making it a total of 120 bee honey farmers for the study. Data were collected through structured questionnaire and data analysis was done using descriptive and inferential statistics such as frequency count, percentages, mean and t-test.

$$z = \frac{\left|\bar{x}_1 - \bar{x}_2\right|}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Where z= calculated value of difference between means
$\bar{x}$= Mean yield score of bee honey income in ₦ before use of the technology
$\bar{x}$= Mean yield score of bee honey income in ₦ after use of the technology
n_1= Sample size of bee farmers before use of technology
n_2= Sample size of bee farmers after use of technology
S_1^2=standard deviation of respondents before use of technology
S_2^2= standard deviation of respondent after use of the technology

RESULT AND DISCUSSION

Socio-economic characteristics of honey bee farmers

The result in Table 1 revealed that 51.67% of the bee farmers have acquired tertiary education. This indicates that the bee farmers in the study area were educated. Higher level of literacy and experience often transform to positive strategies on the bee farmers leading to higher productivity (FAO, 2018). The result showed that majority (55.00%) of the bee farmers had farming experience of 11-20 years. This implies that most of the beekeepers had adequate beekeeping experience which has influenced their use of the improved bee honey technologies. Furthermore majority of the respondents (77.97% are part-time bee farmers. The result on the income showed that majority (45.00%) of the farmers had annual income that fell between ₦300,000 - 400,000 and this implies that honey producers in the study area are poor farmers who still need to improve on their income. Majority (65.00%) of the beekeepers had between 1-10 bee hives and this could be attributed to the high cost of hive construction and their low capital. This finding agrees with that of Uchechukwu, *et al.* (2022).

Table 1: Selected socioeconomic characteristics of Bee Farmers

Variables	Frequency	Percentages
Educational Level		
Primary	4	3.33
Secondary	54	45.00
Tertiary	62	51.67
Farming Experience (years)		
1-10	42	35.00
11-20	66	55.00
21and above	12	10.00
Operational Status		
Part time	92	77.97
Full time	26	22.03
Annual income (₦)		
100,000-200,000	42	35.00
300,000-400,000	54	45.00
500,000 and above	24	20.00
Number of hives		
1-10	78	65.00
11-20	40	33.33
21 and above	2	1.67
Total	**120**	**100.00**

Source: Field survey, 2023

Farmers' income before and after utilization of improved honey production technology

Table 2 shows that the mean income of bee farmers before the utilization of improved honey production technology was ₦222,666.7 while the mean income after use of the technology was ₦377,333.3. This implied that utilization of the improved technology has greatly increased the production output of honey bee farmers. Utilization of improved honey production technology offers opportunity to increase production and income to a large extent.

Table 2: Difference between farmers' income before and after utilization of improved honey production technology

Source of variation	Mean(N)	Standard error
Income before	222,666.7	11721.40
Income after	377,333.3	19435.57

Source: Field survey, 2023

The z-test analysis of farmers' income before and after use of honey bee production technology

Table 3 shows that there was significant difference in income obtained in honey before and after using the improved bee honey production technologies. The z-test statistic shows significant difference ($P < 0.05$) in income obtained from bee honey before and after the use of improved bee production technologies in South-East, Nigeria. From the result, mean of income from honey before the use of improved bee production technologies was ₦222,666.7, while the mean of income after using the improved honey production technologies was ₦377,333.3. There was difference in income of ₦154,666.6 between income before and after using of the improved bee honey production technologies.

The value of z-calculated (6.8148**) is greater than the value of z-tabulated (1.67). This implies that improved honey bee production technologies increased bee farmers' income. Hence, the z-test rejects null hypothesis which stated that there is no significant difference between income from bee honey before and after use of improved honey bee production technologies. Use of improved honey bee production technologies has significantly increased the farmers' income.

Table 3: z-test analysis of farmers' income before and after use of honey bee technology

Optimum	N	Mean	Standard deviation	Standard error	Difference (N)	z-cal.	z-tab
Income before	120	222,666.7	11721.4	128401.5	154,666.7	6.814**	1.67
Income after	120	377,333.3	19435.5	212906.0			

Source: Field survey, 2023. Null Ho rejected significant at 5% level

CONCLUSION AND RECOMMENDATION

The study concluded that improved honey bee production technology has increased the farmers output and income, thus improving their livelihood and economic status. Based on the findings of this study, it is therefore recommended that bee farmers in Abia state should use the improved honey bee production technology to increase their income since it was found in the study that the use of improved bee honey technology increased the farmers' income. Also, bee farmers should increase the number of hive to enable them expand the bee farming size which will in turn bring about increased honey yield and income.

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EFFECT OF HERDSMEN-FARMERS CRISIS ON WOMEN AND GIRLS IN BENUE STATE, NIGERIA

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ABSTRACT
The study evaluated the impact of herdsmen-farmers crisis on women and girls in Benue State, Nigeria. Primary data were obtained from 120 women and girls through personal interviews, focused group discussions (FGDs) and key informant interview (KII). The result showed that the main livelihood activities of women and girls were farming (production of crops and rearing of livestock), processing and sale of farm produce, with a few engaging in petty trading as well. The result holds that the conflict in the area was politically orchestrated. Considering the average mean score, lack of access to health care, displacement, psychological trauma and loss of lives of family members and loved ones stood out as major impacts of herdsmen-farmers conflicts in Benue State. Unanimously, the women and girls solicited for intervention in medical/health services and empowerment in the form of skill acquisition and low or no interest loans. Government at all levels, local institutions and relevant stakeholders should set up a mechanism of ensuring peace, security of lives and properties in these areas and assist the victims of the conflicts through skills acquisition, provision of functional primary health care centers and revive educational system to get the children back to school as quickly as possible.
Keywords: *Herdsmen, farmers, crisis, women, girls, food security*

INTRODUCTION
Violent clashes between herdsmen-farmers are largely viewed as attacks perpetrated by male aggressors while women, girls and children are categorized as vulnerable groups who are caught up in a vicious web of violence. They endure the most of the violent conflicts. Women accounting for such a high percentage of smallholder farmers in sub–Saharan Africa, about 70 percent, implies that they are directly or indirectly affected by the conflicts. The fractured relationship between farmers and herdsmen is not just having a direct impact on the lives and livelihoods of those involved, economic costs and losses from the conflict are significant (Ademola-Adelehin *et al*., 2018). All these have negative implications on the livelihood, social status and role of women within the communities involved in conflict. The conflicts weaken the social capital such that the cohesive forces that bond members of a community are broken. Women play major roles in the cohesion of the community, performing reproductive and community management roles to ensure that the relationship among the community members is sustained. However, the hardships women often experience during and after conflict negatively influence these social cohesion roles.

In Benue State, the frequent clashes between herdsmen and farmers in the predominantly farming areas of the state have resulted in the destruction of lives and farmlands. According to Apenda (2016), nine out of the 23 local government areas (LGAs) in Benue state, namely Guma, Gwer-West, Agatu, Logo, Kwande, Ukum, Tarka and the Northern part of Makurdi are mostly affected. Adetula (2016) as cited in International Crisis Group (2017) said that Benue State seems to be the hardest hit. These clashes are becoming as potentially dangerous as the Boko Haram insurgency in the Northeast. At present, responses to the crisis at both the federal and state levels have been poor.

Despite the fact that some studies have been conducted on herdsmen-farmers lingering conflict in Nigeria, from the literature reviewed, none has precisely focused on the impact this conflict have on the most vulnerable groups - women and girls. Hence, this study evaluated the impacts of herdsmen-farmers crisis on livelihoods of women and girls. The objectives were to ascertain the socio-economic status of women and girls in the study area, identify causes of herdsmen-farmers conflict in the area and ascertain the impact of the conflict on women and girls in Benue state.

METHODOLOGY

This work was conducted in three LGAs - Guma, Gwer-West and Makurdi of Benue State. Two communities from each of the selected LGAs were purposively selected. The communities were selected based on the high frequency of herdsmen-farmers conflict and its effects on women and girls. Primary data used for the study were obtained through personal interviews, focused group discussions (FGDs) and key informant interview (KII). The FGDs and KII were conducted by the researchers and the natives for ease of communication and interpretations. They provided data on general community information, livelihood activities of women and girls, major crops grown by the female farmers, causes of herdsmen-farmers conflicts in the communities, and impact of the conflicts on women and girls.

RESULTS AND DISCUSSION

Causes of Herdsmen-Farmers Conflict in Benue State

This result in Table 1 agrees with the findings of Okereke (2012) and Bello (2013) who listed the causes of the conflict to include theft of cattle, destruction of crops, rape of women, and indiscriminate bush burning. The act of damaging the crops and farm produce by the cattle and the herdsmen is one of the main reasons for the tension between the farmers and herdsmen. According to the women farmers, the herdsmen move their cattle to graze at night, destroying all their farms and crops. Some also move their cattle to feed on harvested agricultural produce stored in the farms, as the women temporary store or keep some harvested crops such as maize, yam, watermelon, cassava and groundnut in the farms for immediate processing before transporting them to the market. However, the herdsmen intentionally move their cattle to feed on those harvested crops. An elderly woman and a farmer at Daudu village explained that *"last year, the herdsmen and their cattle destroyed all my 8 hectares of rice farm. This time around, it was 10 hectares. They intentionally grazed my rice farm even when they were aware that it has not been harvested".*

Any attempt by the farmers to prevent the herdsmen usually leads to conflicts and in most cases the death of the farmers. When the herdsmen kill the farmers, they do not run away for hiding as in previous occasions. Rather, they inhabit the houses of the farmers and use their farms as grazing field for their cattle. The herdsmen further kill any farmer that goes close to the seized houses, or who attempts to repossess their habitation. The study established that, across Guma, Makurdi and Gwer-West LGAs, destruction of crops by cattle ranked as the major cause of the conflicts. However, the discussants accused the ruling class and politicians as the major instigators of the conflict, alleging that the politicians seize the opportunity to acquire land and make more money through camps built for Internally Displaced Person's (IDP). They observed that the politicians were always soliciting for fund from national and international organizations to help control the factors causing the conflicts, but never deployed those funds to anything relating to the conflicts. They gave instances of the government's refusal of the IDPs to return to their homes even when normalcy had returned in the area. They were also restricted from talking to anyone who came to visit for research purposes, unless under strict monitoring. Those suspicious acts agrees with the assertions of the respondents who states that the conflict is now a tool for further enrichment by the corrupt political class.

Table 1: Causes of herdsmen-farmers conflict in Benue State. N=120

Causes	Mean	Remarks
Destruction of farms and crops	4.93	Accepted
Land grabbing and encroachment	4.43	Accepted
Shooting and killing of farmers	4.57	Accepted
Politicians orchestrated	4.71	Accepted
Armed robbery by nomads	2.71	Rejected
Harassment of Nomads	4.43	Accepted
Cattle pilfering/rustling	2.21	Rejected
Rape and sexual harassment by nomads	4.14	Accepted
Indiscriminate bush burning	4.21	Accepted
Threat and intimidation	3.79	Accepted
Water pollution by nomads	3.14	Accepted

Source: Field data, 2022

Effects of the Herder-Farmer Conflict in Benue State

Loss of human lives is one of the major consequences of the continuous conflict, attacks and counter-attacks between farmers and herdsmen in Benue state. It has caused massive death toll of many innocent lives. By implication, loss of family members and relations represent one of the most traumatic experience of women during and after the conflicts subsides. The trauma of losing husbands and children is the greatest psycho-social impact on the women (Hassan, 2018), resulting in post-traumatic stress disorder (PTSD) which manifests in poor mental and physical health, reduced quality of life and difficulties in managing work and family life.

The loss of a husband creates a vacuum in the family and often pushes the bereaved women into unprepared breadwinner roles and decision making for their families. This sudden single parenthood increases women's burden of care often not just for their immediate family but also to provide care for extended family members who were wounded, sick, despairing and displaced because of the conflict. The additional role and associated demand often push families into poverty and dependence, especially when the women lack the skills, experience, and support to take up such huge roles. Lack of resources to meet the demand increases the vulnerability of women to exploitation and forces the children especially girls out of school and sometimes into early marriages. Besides the loss of lives, valuable properties and vast expanse of arable agricultural farmlands are lost during the conflicts, thereby posing serious threat to food security since farmers for fear of attack could no longer go to farm and harvest their farm produce. During the attacks, the women often flee leaving behind cultivated farmlands, which they are often unable to access to harvest the produce. In many cases, women who were able to access their farms after the violence found out that the crops were spoilt, either harvested by other people, or destroyed by cattle. Such losses of farm produce and subsequent rise in food prices in the area have increased poverty and food insecurity (Crisis Group, 2016).

These women are forced to abandon their homes and farmlands for safety and now reside in the IDP camps with little or no care in terms of health care, finances, and general wellbeing. Displaced women and girls suffer the most because they mostly move with the children while men largely move as individuals. Many girls affected by the conflict have not been able to continue schooling. That either their parents or sponsors could not afford the fees, or they are advised to get married or in most cases, the schools were closed-down due to the conflict.

Table 2: Effect of the herder-farmer conflict in Benue State. N=120

Effect	Mean	Decision
Loss of lives of family members/loved ones	4.72	Accepted
Farms were burnt by the herdsmen during the conflict	3.28	Accepted
Crops were harvested/stolen during the conflict	3.73	Accepted
House and properties burnt down completely	4.65	Accepted
Sources of income were destroyed	4.64	Accepted
Livestock and stored food items were destroyed.	4.38	Accepted
Food supply and prizes became unstable	4.14	Accepted
Economic activities were disrupted	4.03	Accepted
Conflict crumbled social gatherings	3.85	Accepted
Displacement of locals	4.80	Accepted
High rate of school outs	3.74	Accepted
No access to health care	4.82	Accepted
Fear of reprisal attacks	4.63	Accepted
Marriage break-ups	2.68	Rejected
sexual harassment, rape and other gender-based violence	3.78	Accepted
Sex for money	4.48	Accepted
Unwanted pregnancies	4.12	Accepted
Early marriage	3.73	Accepted
Psychological Trauma	4.81	Accepted

Source: Filed data, 2022

CONCLUSION AND RECOMMENDATION

Women, girls and children are adversely affected by the conflict and consequently, the farming, economic and social activities are fast deteriorating. However, the attackers do not usually select their victims when they shoot to kill, women and young girls feel and bear the greater brunt of the conflict. The conflict has evidently created many widows, widowers, and helpless young orphans who add to the existing large number of beggars in both rural and urban centers and or become liabilities to other families. These conflicts reinforce circles of extreme poverty, hunger, illiteracy, and moral decadence in the society.

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ASSESSMENT OF BEEKEEPERS' PERCEPTIONS ON PRODUCTION OF BEE HONEY IN SOME SELECTED SOUTHWESTERN STATES OF NIGERIA

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ABSTRACT
This study considered the perceptions of beekeepers on the production of bee honey in Southwestern states of Nigeria. Socioeconomic factors of beekeepers were investigated to deduce their influence on outputs of apiary hives. Multistage sampling technique was used: Oyo, Osun and Ogun states were purposively chosen, and three Local Government Areas were purposively selected from each Senatorial District in the states. Questionnaires were administered to 130 associated beekeepers. Opportunistic approach was used to administered the questionnaires Descriptive statistical analysis was used to analyse data obtained and mean values were separated using Duncan Multiple Range Test. A total of 83 out of the 113 retrieved questionnaires, representing 74% of respondents were males and married. A larger proportion of the beekeepers in the study area had tertiary education certificate 70 (61.9%). A total of 52 (46.0%) respondents were farmers and majority 30 (26.5%) of the respondents earn between 40,000-59,000 Naira only, monthly. The level of variance within the beekeepers' perceptions on production of bee honey was highly significant ($p<0.05$). The mean value of perception on production of bee honey for Ogun state in the rain forest agro-ecological zone was ranked highest (4.2), while Osun state in Southern guinea savanna agro-ecological zone was 3.7. The correlation between socioeconomic factors confirmed that some factors are significantly correlated; while others are highly significantly correlated. Age, marital status and religion were highly significant ($p<0.01$) for the production of bee honey, while educational background and occupation were significant ($p<0.05$). The adjusted R^2 (0.096) between age and perceptions of beekeepers on production of bee honey confirm that age of beekeepers has only 9.6% influence on the individual's output and was returned highest among other socio-economic factors. It was therefore concluded that age is a symbol of experience and maturity to discern best practices in the art of beekeeping and should be reckoned with for better output of hive products.
Keywords: *Socio-economic factors, Beekeepers, Perceptions, Hive products, Output*

INTRODUCTION
The southwestern Nigeria is a region dominated by moist and dry rain forest and guinea savanna agro-ecological zones. A tropical rain forest and guinea savannah region with many beekeepers that have limited experience in colony establishment and management. Incidence of pests and diseases, pesticide poisoning, poor hive and seasonal management, ecological problems and disturbances from Fulani herders and their cattle had been potential problems identified by beekeepers (Hung *et al.*, 2021; Manley *et al.*, 2019). Akinwande *et al.* (2013) reported that environmental factors of high temperature, high rainfall and hive's high relative humidity enhanced the spread of pests and disease pathogens. For Nigerians to have economic breakthrough and improved livelihood in beekeeping, the perceptions of beekeepers on production processes of bee honey should be assessed in various agro-ecological zones to ascertained areas that requires improvement.

METHODOLOGY

The Study Area: The study was conducted in the Southwestern Zone of Nigeria. Southwest zone comprises 6 states, namely: Oyo, Ekiti, Osun, Ondo, Lagos and Ogun. Of which Oyo, Osun and Ogun states were purposively chosen. The weather conditions vary between the rainy season (March - October) and the dry season (November - February); with the dry season accompanied by Harmattan dust, cold dry wind from the northern desert blown into the southern regions around this time. Longitude 30^0 and 7^0E and Latitude 4^0 and 9^0N (Oni and Odekunle, 2016). It has rainfall of 2000-3000mm, and temperature of over 17 degrees Celsius (Uzoh, 2021).

Sampling Technique: A multistage sampling technique was used to purposively select states located within the agro-ecological zones (Rain Forest in Ogun state, Southern guinea savanna in Osun state and Northern guinea savanna in Oyo state) of interest in south-west Nigeria. Three Local Government Areas were purposively selected, one from each Senatorial District in each State for even sampling of locations. A total of 135 questionnaire were administered. Opportunistic approach was used to choose 45 Beekeepers (45), from beekeepers Association, in each Local Government Area chosen, for consultation and administration of questionnaire, which elicited information on socio-economic data and production system.

Data Analysis: Descriptive statistical analysis (frequencies, percentages, and means) was used to analyse data obtained and Duncan Multiple Range Test was used to separate the means.

RESULTS

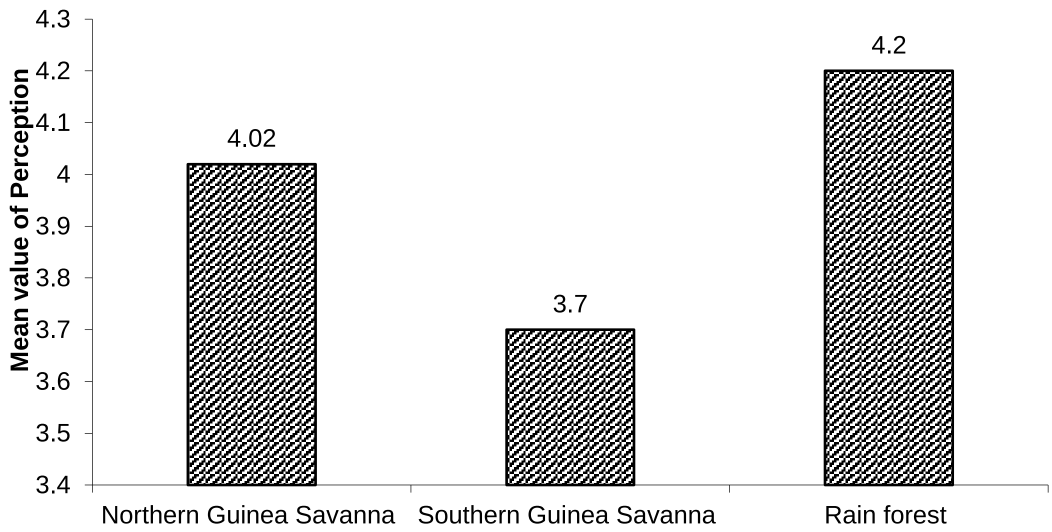
For this study, a total of 135 questionnaire were administered, of which 113 (83.7%) were retrieved. Each state was assigned 45 questionnaire, of which 38 in Oyo, 41 in Osun and 34 in Ogun states were retrieved respectively. About 38 (33.6%) of the respondents were from Oyo state whereas, 41 (Osun state) and 34 from Ogun state (Table 1). A total of 83 out of the 113 respondents were males compared to 28 females. There were more of tertiary education certificate holders (70), followed by secondary (29) and primary (12) education certificate holders. Yoruba ethnic group was highest (108 representing 95.6%) compared to Hausa 3 (2.7%) and Igbo 2 (1.8%) respectively. Out of the total respondents, 57 (50.4%) were Islam, 55 (48.7%) were Christians and 1 (0.9%) was a traditionalist. A total of 52 (46.0%) respondents are farmers, 23 (20.4%) are civil servant, students 19 (16.8%), while retirees are 9 (8.0%) and Artisan and trader are both 5 each (4.4%). Majority, 30 (26.5%) of the 113 respondents receive between 40,000-59,000 Naira only, monthly, followed by 15 (13.3%) for those receiving 100,000 Naira and above. The least among the group (1 representing 0.9%) are those receiving between 80,000 – 99,000 Naira only and less than 20,000 Naira only. The remaining 45 (39.8%) respondents (missing values) did not disclose their monthly realizations. In Table 2, The level of variance within the beekeepers' perceptions on production of bee honey was highly significant ($p<0.05$). The mean value of perception on production of bee honey (Figure 1) for Ogun state in the rain forest agro-ecological zone was ranked highest (4.2) (Table 3); followed by that of Oyo state in the Northern guinea savanna agro-ecological zone with 4.02; whereas that of Osun state in Southern guinea savanna agro-ecological zone is 3.7. The correlation between socioeconomic factors confirmed that some factors are significantly correlated; while others are highly significantly correlated. For instance, gender and age with ethnic group and age are both significantly correlated; while marital status and age, religion and local government area, religion and age, occupation and gender with occupation and marital status are all highly significantly correlated (Table 4). The result further shows that to produce bee honey; age, marital status and religion were highly significant ($p<0.01$); while educational background and occupation are significant ($p<0.05$) (Table 5). The adjusted R^2 (0.096) between age and perceptions of beekeepers on production of bee honey shows that the age of the beekeepers has only 9.6% influence on the individual's output and was returned highest among other socio-economic factors. The adjusted R^2 (0.064) between marital status and perceptions of beekeepers on production of bee honey shows that the marital status of the beekeepers had only 6.4% influence on the individual's output. Likewise, the adjusted R^2 (0.051) between religion and perceptions of beekeepers on production of bee honey shows that religion of beekeepers had only 5.1% influence on individual's output. Educational background ($R^2 = 0.039$) and occupation ($R^2 = 0.030$) of beekeepers had 3.9% and 3.0% influences respectively on individual's output.

Table 1: Socio-economic characteristics of Beekeepers in the study area

Variable	Response	Frequency	Percentage
	Oyo / Northern Guinea savanna	38	33.6
	Osun / Southern guinea savanna	41	36.3
	Ogun / Rain forest	34	30.1
	Total	113	100.0
	less than 30	25	22.1
	30-39	22	19.5
	40-49	29	25.7
	50 & above	37	32.7

Total	113	100.0
Male	83	73.5
Female	28	24.8
I prefer not to say	2	1.8
Total	113	100.0
Single	25	22.1
Married	83	73.5
Divorced	2	1.8
Widow or Widower	3	2.7
Total	113	100.0
Primary	12	10.6
Secondary	29	25.7
Tertiary	70	61.9
No formal Education	2	1.8
Total	113	100.0
1-5	15	13.3
6-10	24	21.2
11-15	34	30.1
16-20	15	13.3
21 and above	25	22.1
Total	113	100.0
Yoruba	108	95.6
Hausa	3	2.7
Igbo	2	1.8
Total	113	100.0
Christianity	55	48.7
Islam	57	50.4
Traditional	1	0.9
Total	113	100.0
Civil Servant	23	20.4
Artisan	5	4.4
Trader	5	4.4
Farmer	52	46.0
Student	19	16.8
Retiree	9	8.0
Total	113	100.0
less than 20,000	1	0.9
20,000-39,000	11	9.7
40,000-59,000	30	26.5
60,000-79,000	10	8.8
80,000-99,000	1	0.9
100,000 & above	15	13.3
Total	68	60.2
Missing System	45	39.8
Total	113	100.0

Source: Field survey, 2023



*Significant (p<0.05)
Figure 1. Perception of beekeepers on production of bee honey

Table 2: ANOVA of perception of beekeepers on production of bee products in the three agro-ecological zones.

State	N	Mean	Std. Deviation	Std. Error
Oyo	38	4.0200	0.31297	0.05077
Osun	41	3.7963	0.45888	0.07166
Ogun	34	4.2145	0.30060	0.05155
Total	113	3.9974	0.40433	0.03804

There was a significant difference on the perception of respondents on production of bee products in the study (p<0.05), see follow up test below

Table 3: Duncan follow up test on the separation of mean value of perceptions of beekeepers on production of bee honey

Locations	N	Mean
Osun	41	3.7963[a]
Oyo	38	4.0200[b]
Ogun	34	4.2145[c]

Table 4: Correlation between the socio-economic factors.

Socio-economic factor		**Age**	**Marital Status**	**Educational Background**	**Religion**	**Occupation**
	Pearson Correlation	1				
	Sig. (2-tailed)					
	Pearson Correlation	.549**	1			
	Sig. (2-tailed)	.000				
	Pearson Correlation	-.069	-.126	1		
	Sig. (2-tailed)	.470	.185			
	Pearson Correlation	-.299**	-.004	.064	1	
	Sig. (2-tailed)	.001	.969	.501		
	Pearson Correlation	-.142	-.315**	-.026	.162	1
	Sig. (2-tailed)	.135	.001	.783	.087	

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is highly significant at the 0.01 level (2-tailed).
Source: Field survey, 2023.

Table 5: Regression equations on perceptions of beekeepers in Oyo, Osun and Ogun States on production, quality and utilization of bee honey

S/N	EQUATION	SIG.	RMSE	R	R^2
	Perception of beekeepers on production of bee products				
1	3.639+0.008(Age)	0.001	0.3845	0.104	0.096
2	3.646+0.190(Marital Status)	0.004	0.3913	0.072	0.064
3	4.316-0.125(Educational Background)	0.02	0.3964	0.048	0.039
4	4.287-0.190(Religion)	0.009	0.3939	0.06	0.051
5	4.181-0.051(Occupation)	0.038	0.0398	0.038	0.030

Source: Field survey, 2023.

DISCUSSION

Bee honey production is practiced in Oyo, Osun and Ogun states and the producers are basically between the ages of 30 – 50 years (Table 1). This observation is like the report of Aiyeloja *et al*. (2010) whose preliminary investigations in Ondo and Osun indicated that bee honey production is widely practiced in south-west Nigeria and Babatunde *et al.* (2007), in Oyo state, who likewise stated that majorities of beekeepers were between 36 and 45 years of age. However, Chanthayod *et al.* (2020) in the Laos reported between 40 to 60 years. It was stressed that people, both at youthful age and middle age were involved at different stages of bee honey production. This could be purely due to the nature of their community, endowed with forest containing varieties of trees (Oil palm *Elaeis guinneensis*, Cocoa *Theobroma cacao*, Sunflower *Helianthus annus*, and Queen Elizabeth/Ewe Akintola/Ewe Awolowo *Chromolaena odorata*) that produces nectar required by bees to synthesis bee honey.

It was observed that more males were involved in the production of bee honey than females. This observation is like the report of Bekuma (2018) and Obayelu *et al*. (2020) who concluded that there is gender gap in agricultural labour participation where males played dominant roles compared to their female counterparts. In a similar trend, more married respondents engaged in bee honey production. This observation is consistent with the report of Tadesse *et al.* (2021) and Akinmulewo *et al.* (2017) where they both stated that greater percentage of respondents were married as against the remaining few singles. This could be related to the fact that married people have more responsibilities to cater for; hence, must embark on beekeeping though scary for many, because of bee stings. The respondents had educational background ranging from primary to tertiary level. This observation is similar to the report of Bihonegn and Begna (2021), in Ethiopia, which stated that greater percentage of beekeepers had primary to secondary school level education; that can significantly influence the effectiveness of improved beekeeping adoption. More Yoruba respondents are apparently involved in bee honey production in the study area. This observation is justified by the fact that the region is Yoruba land and Yoruba indigenes dominated.

Beekeepers in the south-west, Nigeria, practice majorly Islam and Christianity as a religion; with few that are into traditionalist religion. This support the findings of McKinnon (2021) who reported that the major religion practiced in Nigeria are Christianity, Islam, and ethnic religions. The beekeepers were mostly farmers, though there are other professions like civil servant, students, retiree, trader and artisans. This is consistent with previous reports (Paul, 2022; Camden, 2015) that most beekeepers are also farmers. Camden (2015) affirmed that beekeepers who were formerly classified under state tax code as a service, like doctors or lawyers are now officially designated as farmers, a recognition the industry has sought for years. It was also observed that the larger percentage of the respondents earn between forty thousand Naira to fifty-nine thousand Naira only (an equivalent of ₦480,000.00 to ₦708,000.00 per annum). This finding is higher than that of Akinmulewo *et al.* (2017) who reported majority annual income of three hundred thousand Naira to three hundred and ninety-nine thousand, nine hundred and ninety-nine Naira only (₦300,000.00 to ₦399,999.00) for the beekeepers in Federal Capital Territory (FCT) communities, Abuja. This would go a long way to determine the extent to which the respondents would be involved in bee honey production or beekeeping expansion. With the prevailing economic situation in Nigeria today, this amount might be insufficient to cater for various family needs e.g. rent, food, children’s school fees and other bills; talk less having extras to construct bee hives.

The building of beehive was generally accepted to be the first activity in the process of bee honey production. It was confirmed that whatever level of involvement in the process of beekeeping, participants are bound to gain as all level of activities yield its own benefits. It was observed that majority of the beekeepers used Kenyan top bar hives. This is in line with the findings of McMenamin *et al.* (2017) and Onwubuya *et al.* (2013) that reported uses of Kenyan top bars by beekeepers. For instance, McMenamin *et al.* (2017) reported that the rate of occupation of Kenyan top bars followed Langstroth and is ahead of traditional log hive. The larger majority of beekeepers harvest bee honey from their hives only once in a year. This correlate with the findings of Godifey *et al.* (2018) whose overall majority also harvested once a year. The quantity of bee honey harvested varies by individual beekeeper's capacity and season, but majority harvested less than fifteen litres of bee honey per hive per year. This is consistent with the findings of Falade *et al*. (2012) where 4litres and 12litres were harvested per hive per year after a period of 4months and 6 months, respectively. Majority of the beekeepers possessed less than ten hives. This is far lesser compared to the findings of Akinmulewo *et al.* (2017) who reported that in FCT, Abuja, each beekeeper possessed 36 beehives on average. In Table 2, the level of variance within the beekeepers' perceptions on production of bee honey was highly significant ($p<0.05$). The mean value of perception on production of bee honey (Figure 1) for Ogun state in the rain forest agro-ecological zone was ranked highest (4.2) (Table 3); followed by that of Oyo state in the Northern guinea savanna agro-ecological zone with 4.02; whereas that of Osun state in Southern guinea savanna agro-ecological zone is 3.7.

The perception of respondents differs on processes of production of bee honey. The mean value of perception varies among beekeepers in the various agro-ecological zones in south-west Nigeria. Ogun state beekeepers in the rain forest agro-ecological zones have the highest mean value of perception, this affirmed that they have a more divergent opinion about the production processes of bee honey. While Osun state in the southern guinea savanna agro-ecological zone have the least mean value of perception, which confirm that they have a more convergent view about the production processes of bee honey. The mean value of perception of the respondents across Oyo, Osun and Ogun states is found to be significant and an ad hoc test conducted ranked Osun state beekeepers as having the most convergent perceptions about the production processes of bee honey; while Ogun state beekeepers has the least.

The correlation between socioeconomic factors confirmed that some factors are significantly correlated; while others are highly significantly correlated. For instance, gender and age with ethnic group and age are both significantly correlated; while marital status and age, religion and local government area, religion and age, occupation and gender with occupation and marital status are all highly significantly correlated (Table 4). The regression equations established the various level of influences that beekeepers' view has on the methods of production of bee honey in Oyo, Osun and Ogun states (Table 5). The socioeconomic factors that are highly significant are age, marital status and religion, of which age was returned highest having the most influence on production of bee honey.

CONCLUSION

The awareness about the importance of honey for food and medicinal purposes is rising and consequently there are increasing demand. Despite all hurdles in the production system, extant beekeepers should brace up and exchange ideas with others in the industry to optimize their perceptions on bee honey production processes. It was therefore concluded that age is a symbol of experience and maturity, to discern best practices in the art of beekeeping and should be reckoned with for better output of hive products.

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"LAFIA"

SUB-THEME 12:

Food and Nutrition Technology Development in Nigeria

EVALUATION OF PRODUCTION FUNCTION AMONG CASSAVA FARMERS IN SOUTH-EAST, NIGERIA.

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ABSTRACT
This study examined the production function among cassava farmers as a means of strengthening agriculture for food and nutrition security in south-east, Nigeria. The cardinal objective of this study was to determine how allocative efficiency of resource use can bring about knowledge creation and transfer among cassava farmers for food and nutrition security in the study area. Two hundred and fifty respondents were randomly selected from the five south eastern states using multi-stage random sampling technique. Primary data for the study was collected using a well-structured questionnaire and interview schedule. Multiple regression model was used to analyze the objective of the study. The multiple regression analysis result had coefficient of determinations (R^2) of 0.764. Thus, there is need for appropriate policy formulation in order to ensure cassava farmers' access to credit facility, educational programmes, labour saving devices and extension services.
Keyword: *Production function, Resource use, Cassava farmers, Strengthening agriculture*

INTRODUCTION
Cassava production is a powerful weapon for poverty reduction and sustainable economic development in the south eastern region of Nigeria. The consumption of cassava by most households in Nigeria, especially in the South-east is in processed form of the root like gari, fufu, starch, fresh and dry flakes (abacha*)* and tapioca (Ibekwe *et al*., 2012). In addition, FAO, (2019) reported that cassava serves as cash crop to farmers in the producing areas in the country, as about 45% of it is sold to upset innumerable family earnings needs. Apart from human consumption and cash income purposes, cassava could be used as livestock feed and industrial needs (for plywood, textile and bakery industries, and cassava starch for pharmaceutical, industrial alcohol, processed foods and laundry industries (Esheya, 2019).

In 2018, global production of cassava stood at more than 278 million tons, of which Africa produced 170 million, accounted for over 56% of world production. In the same year under review, Nigeria produced 60 million tons, accounting about the world's largest producer (approximately 22% of global production) with a 37% increase in the last decade ((FAO, 2019). Nevertheless, despite the cassava production feat of Nigeria, yet the average yield per land area of the crop has remained relatively low, with average yield per hectare of about 7.7 metric tonnes compared with 23.4 metric tonnes and 22.2 metrics in Indonesia and Thailand, respectively (FAO, 2019). The low yield of the crop according to Otekunrin and Swawica, (2019) could be correlated to low productivity, hence aggravating poverty and food insecurity. Low productivity in agriculture in general could be enhanced through efficiency in resource use. The analysis of efficiency is generally associated with the possibility of farm production to attain optimal level of output from a given bundle of input at least cost (Gani and Omonoma, 2012).

Since time immemorial, agribusiness managers have sought a competitive advantage that would allow it to serve customers as efficiently as possible, maximize profits and develop loyal customers. How and where farmers search for the knowledge to fuel their innovation processes has been a focus of extensive research over the past decade. Collaboration between farmers and agro-companies constitutes planned knowledge spillovers or exchanges, as firms work together at particular stages in the production chain.

Organizations that often view knowledge as their product adopt the transfer of such product (newly discovered knowledge) as a business strategy as other competing industries will view them as leading in discovering creative ideas. In reality, knowledge is created in the organization by socialization as a result of communication and interactions such as discussions, sharing experience, simulation, practice observation and other social contacts that could exist among members of an organization. Knowledge could also be created in an organization by externalization which is a process that converts tacit knowledge to explicit knowledge in the shapes of concept, metaphors, hypothesis, description and models (Project Reserve, 2023).

Knowledge creation is the formation of new ideas through interactions between explicit and tacit knowledge in individual human minds. It involves socialization (tacit to tacit), externalization (tacit to explicit), combination (explicit to explicit), and internalization (explicit to tacit). Knowledge transfer is the conveyance of knowledge, expertise, skills and capabilities from universities as the academic knowledge base to companies or organizations in need of the knowledge, such as non-government organizations, commercial and industrial sectors, and various non-academic beneficiaries (Project Reserve, 2023). Thus, this study was undertaken to determine how allocative efficiency of resource use can contribute to the creation and transfer of knowledge among cassava farmers for strengthening agriculture for food and nutrition security in south- east Nigeria.

MATERIALS AND METHODS

The study was carried out in the five south eastern states of Nigeria namely Abia, Anambra, Ebonyi, Enugu and Imo states. Five (5) local government areas were drawn from each of the states while 10 registered farmers were randomly selected from each of the 25 selected local government areas to obtain a total of 250 cassava farmers from the list of registered cassava farmers obtained from the respective local government headquarters. Thus, a sample size of 250 cassava farmers were sampled through a multi-stage purposive sampling and interviewed. Information was obtained directly from the cassava farmers through interviews using interviewer-administered structured questionnaires. Multiple regression model was used for data analysis.

Multiple regression is used to obtain allocative efficiency indices b_i coefficient was estimated by means of ordinary least squared regressions method. The explicit production function was estimated by:

$Y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + e$ ……… (1)

Where: Y = value of cassava output (₦),

x_1 = farm size (ha),

x_2 = labour (mandays),

x_3 = cassava stem (bundle/kg),

x_4 = fertilizer (kg),

x_5 = capital (₦)

$x_1 – x_5$ = coefficient of the parameters to be estimated,

e_1 = error term

b_0 = coefficient.

Four functional forms of the multiple regressions were employed in order to select the one that has provided the best fit. The functional forms tried were:

Linear function: $Y = b_0 + b_1 x_1 b_2 x_2 + b_3 x_3 + b_4 x_4 + b_5 x_5 + ei$ . . ………………. (2)

Double log function Y: $\ln(y) = \ln b_0 + b_1\ln x_1 + b_2\ln x_2 + b_3\ln x_3 + b_4\ln x_4 + b_5\ln x_5 + ei$ ……… (3)

Semi log : $Y = \ln b_0 + b_1\ln x_1 + b_2\ln x_2 + b_3\ln x_3 + b_4\ln x_4 + b_5\ln x_5 + ei$ ………… (4)

Exponential function: $\ln Y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + ei$………… (5)

The choice of the double log function was based on the magnitude of the R^2 value, the high number of significance, size and signs of the regression coefficients as they conform to a priori expectation.

RESULTS AND DISCUSSION

Allocative efficiency of resource use among cassava farmers

This section examined the allocative efficiency of resource use indices for cassava farmers in south east, Nigeria. Table 1 shows the result of multiple regression analysis.

Table 1: Estimated multiple regression production function for cassava farmers

Variable	Linear	Exponential	Double Log+ (Cobb Douglas)	Semi Log
Constant	9.689	6.6477	6.074	3.123
	(4.790)***	(3.009)***	(3.741)***	(3.2001)***
Farm size	1.413	0.169	0.196	0.799
	(2.227)**	(0.027)	(3.201)***	(0.009)
Cassava Cutting	0.431	0.690	- 0.108	1.021
	(0.547)	(0.508)	(2.111)*	(-0.423)
Fertilizer	0.427	0.0189	0.473	-2.123
	(-1.536)	(2.347)**	(3.331)***	(2.344)**
Labour	0.933	0.471	0.182	-0.315

	(3.082)***	(4.0123)***	(1.442)***	(0.308)
Capital	-0.519	-0.449	0.162	0.024
	(-2.733)	(-1.049)	(0.226)	(0.019)
R^2	0.628	0.557	0.764	0.655
F Value	42.486***	36.641***	56.782 ***	54.771***

Source: Field Survey, 2021; *, **, *** significant at 1.0%, 5.0% and 10.0% levels of probability respectively; figure in parenthesis is the t-ratio.

The multiple regression analysis result had coefficient of determinations (R^2) of 0.764, which indicated that 76.4% of the variation in the output of cassava was explained by the model and the remaining 23.6 % were due to error term. The statistically significant F- ratio value of 56.782 of the regression model shows that variation in cassava enterprise was jointly influenced by the independent variable incorporated in the equation. The coefficient of cassava cutting (-0.108) was negative and significant at 10%, implying that a unit increased in the cassava cutting will result to a decrease in cassava output by -0.108 %. The sign identity of the variable could be related to over utilization of the factor input in relationship to other productive resources such as fertilizer, pesticides and labour used in cassava production. The over utilization of the input could be because of numerous cassava varieties in the study area made available by Agricultural Development Programme (ADP) extension agent and National Root Crop Research Institute (NRCRI) Umudike, Abia State experimental stations (Nnadozie *et al*., 2015).

On the contrary, the coefficients of fertilizers (0.473), labours (0.182) and farm size (0.196) were positive and significant at 1% respectively, implying that increasing the level of either fertilizers, labours and herbicides or all will result to a significant increase in the cassava output in the study area. This concurs with Ume *et al*. (2018) who stated that agricultural productivity can be enhanced through an increase in the quantity of a particular input.

CONCLUSION AND RECOMMENDATIONS

This study presents a general overview for understanding how production function can contribute to knowledge creation and transfer among cassava farmers for strengthening agriculture for food and nutrition security in the study area. The result of the allocative efficiency showed that none of the respondents achieved absolute efficiency of resource use as they either underutilized of over utilized the farm resources. The over utilization resources were fertilizer, farm size and capital, while the underutilized resources were cassava stem cutting and labour. There is need for government at all levels to encourage financial institutions to provide credit facilities to cassava farmers so as boost farm productivity and strengthen agriculture. Besides, extension agents should train cassava farmers on improved production management practices to enable them use the available resources effectively and efficiently to enhance food and nutrition security in the study area.

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DETERMINING THE VIABILITY OF SMALL-SCALE DATE PALM (*PHOENIX DACTYLIFERA* L.) PRODUCTION IN DUTSE AND KIYAWA L.G.A., JIGAWA STATE, NIGERIA

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ABSTRACT
This study was conducted to determine the viability of date palm production. To achieve this objective a field survey was carried out and information were collected regarding various inputs and outputs and their prices and much other information. 113 farmers were verified for this study as small-scale date palm producers, two (2) wards and three (3) villages each were purposively selected from Dutse and Kiyawa L.G.As. NPV and BCR were used to determine the profitability of the date production. The result reveals that 86.7% had their trees in scattered/different locations and 81.4% possess the date palm tree by planting. The NPV was estimated to be ₦126,557.55 per 14 tree stands and BCR of 1.44 meaning for every ₦1 invested there is ₦1.44k revenue, this indicates that the date palm production is profitable in the study area. Positive NPV also highlight that the date palm cultivation will continue to provide positive returns for a long period of time. It was recommended that improved technologies should be channeled to the growers in the area so that they will improve their production and productivity, government should encourage the growers by policy and subsidy of production inputs.

INTRODUCTION
Date palm (*Phoenix datylifera* L.) is thought to have been introduced to Nigeria in the early 17th century via the Trans-Saharan trade route from North Africa and the Middle East by traders and the Muslim pilgrimage to the holy cities of Mecca and Medina (Sanusi *et al*., 2014). Since that time, date palm farming has only been recognized in the northern region of the country in orchards, compounds, and homesteads. It is grown mainly as an ornamental for aesthetic purposes in the southern part (Omoti and Okolo, 2000). Dates are produced in hot, dry regions of the world and marketed as high value confections worldwide. In the vast majority of the world's desert regions, dates are regarded as an important subsistence crop (Dada *et al*., 2012). The Nigerian Institute for Oil Palm Research has so far conducted research on the yearly date production level in several states of the nation, which would give data for research planning, industry growth and development (Dada *et al*., 2012).

The Nigerian Institute for Oil Palm Research was granted the responsibility to conduct research on oil palms by the Nigerian Institute Act No. 33 of 1964. Major research efforts started in the early 1980s when prospection/diseases surveys were carried out by breeders, crop protectionists, soil scientists, and agricultural economists in various northern regions. Significant progress has been made in crop protection, agronomy, soil chemistry, breeding, and nutrition (NIFOR, 2008). Despite the existence of local varieties with good fruit quality and favorable soil and climate conditions for date production, date palm farming is still at the subsistence level, and domestic production is only estimated at 19580 metric tons (Sani *et al.,* 2010).

According to Harbo and Isiaku (2007) an average fruiting female palm in Nigeria can produce 40–60 Kg/year using a recommended number of 200 stands per hectare. Dates are nutrient-dense because they are abundant in carbohydrates, fiber, potassium, vitamins, and minerals; they are also low in fat, almost cholesterol- and sodium-free. Nigeria has a great potential to expand its date palm output, increase productivity, becomes a net exporter of date fruit (Dada *et al*., 2012). Production of date palm in Nigeria has not yet been determined due to the non-availability of annual date production statistics in the country (Dada *et al*., 2012). Information on date production levels in nine states in Nigeria is available, viz; Bauchi 6000 mt, Adamawa 600 mt, Borno 1000 mt, Gombe 1500 mt, Jigawa 5000 mt, Kano 6000 mt, Plateau 100 mt, Taraba 200 mt and Yobe 2000 mt (NIFOR, 2008) since then the information has not been updated. The Nigerian date palm sector has the potential to export date fruit and its by-products to the international market, but Nigeria is now more of a consumer and importer of date fruit, and the absence of plantations and information on the production capacity prevents the nation from being one of the top exporters of date products in west Africa (Mani, 2014).

As with any economic analysis, the profitability of an investment is based on a comparison of the returns and cost of the investment. Hence, the profitability of crop production depends on reducing the farming cost as much as possible, and at the same time maximizing the income from the sale of crop. The potential of earning and maintaining profitability serves as an incentive for farmers to be creative and efficient. Profitability stimulates risky ventures and drives farmers to develop ways of cutting cost and improving technology always in an effort to satisfy consumer interest (Troke, 2008). Profitable agriculture is dependent on productive soil and date palm production is not an exception. This study attempts to assess the cost of date palm production and to assist producers in determining how the date tree they are cultivating affects profitability.

METHODOLOGY

The study area: With an estimated population of roughly 246,143 and 172,913, Dutse and Kiyawa Local Government Areas are located in Jigawa State, Nigeria, between latitude $11^0$42'04"North - $11^0$47'05"North and longitude $9^0$20'31"East - $9^0$36'30"East (Jigawa State, 2017). Dutse and Kiyawa share a border, as well as an inter-state border with Kano and Bauchi state. This provides a unique opportunity for inter-state trading in date palm fruit produced in the area and other surrounding states. Annual rainfall is estimated to be between 600mm - 1,000mm with an average of about 650mm over the last few years. Temperature ranges from 10^0C during the harmattan season to about 42^0C during the dry season and annual mean relative humidity of 30.8%.

Sampling Procedure: Due to the concentration and high intensity of date palm production in Dutse and Kiyawa, six villages were randomly selected from both L.G.As. A simple census was conducted in each community based on the owners of date palm trees, and a total of 113 were identified and verified to be small-scale date palm growers, which were used for assessing information on production costs and income-related factors.

Data Collection: Primary data were used as a source of information in this study. The data was collected with the aid of a structured questionnaire administered to the date palm producers.

Data Analysis: Simple descriptive statistical tools such as frequency and percentages were used for the socio-economic characteristics of the farmers, and Net Present Value and Benefit cost ration was used to estimate the costs and benefit of date palm production.

Model Specification: Date trees do not start yielding fruit until the fifth to eighth year of their establishment, therefore the annual fruit harvest is separated into two different yield cycles: the first from the eighth to the end of the thirteenth year, and the second from the fourteenth to the twenty-fifth year. The average annual harvestable number of date fruits per tree is the primary difference between the two cycles. In comparison to the first cycle, the yield is significantly higher in the second. It was also assumed that the selling price of date produce and input prices would remain constant during the course of the business. This approach is commonly used to avoid the complications that may occur when attempts are made to include inflation in input and output prices. The costs were divided into four categories: the initial year of establishment, years 2 to 7, years 8 to 13, years 14 to 19, and years 20 to 25. The cost of various inputs used in growing date palm was determined using the methods adopted by Sarfraz *et al.* (2006).

In the case of the date palm tree being a perennial crop, net present value (NPV) and benefit cost ratio (BCR) budgeting tools were employed to estimate the profitability of date palm cultivation in the study locations.

Net Present Value (NPV): is specified as; $NPV = \frac{B_0 - C_0}{(1+i)^0} + \frac{B_1 - C_1}{(1+i)^1} + \cdots + \frac{B_t - C_t}{(1+i)^t}$

Benefit Cost Ratio (BCR); $BCR = (\frac{B_0}{(1+i)^0} + \cdots + \frac{B_t}{(1+i)^t}) \div (\frac{C_0}{(1+i)^0} + \cdots + \frac{C_t}{(1+i)^t})$

Where: NPV= Net Present Value, t = year, B = benefits, C = cost, i=discount rate. BCR = Benefit Cost Ratio,

RESULT AND DISCUSSION

The results of the analysis presented in Table 1 show that 86.7% of the respondents having their date trees in scattered areas, including homesteads and other people's farms near and far. It also shows that the majority of respondents obtained their trees through planting and inheritance.

Table 1: Descriptive Statistics of Qualitative socioeconomic characteristics

Items		Frequency	Percent %
Sex of the respondent	Male	113	100.0
Trees at scattered locations	Yes	98	86.7
	No	15	13.3
Self-Planting	Yes	92	81.4

Items		Frequency	Percent %
	No	21	18.6
Possessed by Purchase	Yes	37	32.7
	No	76	67.3
Possessed by Inheritance	Yes	73	64.6
	No	40	35.4

Source: Field Survey, 2021

The initial costs of establishing a date palm plantation were computed using various input costs reported by 113 date palm growers in Dutse and Kiyawa L.G.A. The results in Table 2 show the initial costs of establishing a date palm plantation with an average of 14 trees. The compiled results indicated that the total variable costs on initial development of date palm accumulated to ₦84,300/14trees. The details regarding the economic analysis of the initial costs on date palm plantation development indicate that construction of tube-well for irrigation were the cost items with the highest amount costing about 71% of the initial cost.

Table 2: Estimated cost for establishment and maintenance of date palm

	Years				
Items	1 year	2 - 7 years	8 - 13years	14 - 19 years	20 – 25years
Planting Materials	6,900.00	0	0	0	0
Organic Manure	4,000.00	30,400.00	36,000.00	42,400.00	42,400.00
Plant Protection Measures	3,900.00	32,100.00	40,800.00	47,600.00	47,600.00
Irrigation	60,000.00	42,000.00	60,000.00	70,000.00	70,000.00
Labour	9,500.00	12,000.00	13,800.00	16,100.00	16,100.00
Total	84,300.00	116,500.00	150,600.00	176,100.00	176,100.00

Source: Field Survey, 2021

According to Barreveld (2011), date palms can last for more than 100 years and start increasing their fruit yields between the ages of 6 and 20 years, reaching full maturity in 12-13 years. Table 3 reveals the estimated cost of date palm production starting with the establishment cost (year 0-1) estimated at ₦84,300.00 and the annual maintenance for a period of 25 years. The maintenance cost continues to increases as it grows. Eight (8) years was used for the date to start fruiting this is based on the report from the farmers and this might be due to the fact that most of the varieties grown in the area are local varieties. At the ages before it start fruiting the maintenance requirement is only organic manure, protection (by fencing and pesticide application) where necessary, then irrigation which is the most important though date palm can resist harsh climatic conditions. But after it start yielding the maintenance cost will increase more especially with regards to protection measures, at this stage there is need to protect the fruits from pest, wind and sometime rain to avoid losing the fruit.

As previously mentioned, date trees begin fruiting between the ages of 4 and 5 years for improved varieties and 5 to 7 years for local varieties. Nevertheless, based on the responses of the farmers contacted, dates begin fruiting 8 years on average after planting. Since it was believed that the date palm may produce fruit that could be marketed at this age, the output and returns were taken from 8 years onward. Table 3 shows that the yield in the second age group, between 8 and 13 years, can reach 1358kg on average for 14 trees, and a total of ₦679,000.00 revenue can be realized. The third and fourth category yield keeps increasing. The trees will not stop producing at this age, but will instead continue to fruit for a longer period of time.

Table 3: Projected Output and Revenue

Items	**Output Quantity (kg/14stands)**	**Total Revenue (N/14stands)**
year 8 – 13	1358	679,000.00
year 14 – 19	2800	1,400,000.00
year 20 – 25	2940	1,470,000.00

Source: Field Survey, 2021

Table 4 summarises the viability result for date palm production investment in the study area. It is well known that date production is a long-term enterprise, and for the purposes of this study, the date palm generates income eight (8) years after planting. Costs and returns, on the other hand, do not serve as true yardsticks for deciding whether or not to invest in date palm production. This is because the costs and returns from date trees are not comparable unless such costs and returns are discounted. The cash flow statement was prepared by computing the PVC and PVR at a 10% discounting rate. PVR was assumed to be zero for the period of 1 to 7 years because date trees usually don't bear fruit during this time (if fruiting occurs during this time, it is insignificant). The NPV was estimated to be ₦126,557.55 per 14stands and BCR was 1.44, this demonstrates that investment in date palm cultivation could be considered significant and economically justifiable. Based on the BCR, investing one Naira in date trees yields a return of ₦1.44, which is acceptable from an economic point of view. The estimated 1.48 BCR for date palm farming by Sarfraz *et al*. (2006) and 1.56 BCR for oil palm by Ukwuteno et al. (2018) are comparable to the estimates obtained in this study.

Table 4: Financial Analysis of date palm

Items	**Years**			
	1-7yrs	**8-13yrs**	**14-19yrs**	**20-25yrs**
Capital cost (N/14trees)	220,216.69	-	-	-
Maintenance Cost	-	150,600.00	150,942.84	150,942.84
Total Cost (N/14stands)	220,216.69	150,600.00	150,942.84	150,942.84
Total Revenue (N/14stands)	-	679,000.00	1,400,000.00	1,470,000.00
Net Revenue (N/14stands)	-220,216.69	528,400.00	1,249,057.16	1,319,057.16
Present Value of total cost	178,828.48	56,096.93	31,737.34	17,914.90
Present Value of Net Revenue (PVNR)	-178,828.48	173,658.70	259,750.50	156,554.48
Net Present Value (N/14stands)	126,557.55			
Benefit Cost Ratio (BCR)	1.44			

Producer Price = ₦500.00/Kg fresh fruit, Discount rate = 10%

CONCLUSION AND RECOMMENDATIONS

According to this study, a small scale date palm farmer with an average of 14 tree stands can make discounted gross revenue of ₦233,333.00 to ₦245,000.00 per year with maintenance costs ranging between ₦25,100 and ₦25,157.14. Based on this research, it was concluded that date palm production is a profitable enterprise with a 1.44 BCR, but production of date palm is at subsistent level in the study area.

Date palm production is a profitable venture which must be encouraged and at the same time is less capital intensive. Effort should be put to restore the date production at a capacitated level. Research institute in the area should disseminate the new and improved technologies for date palm production to the date palm farmers in the area. Government could encourage transformation of date palm industry through subsidy and other incentives that will enhance date production in the area. Due to Perishability nature of the date fruits modern harvesting technologies and proper packaging, storing and transporting facilities should be provided to reduce postharvest loss.

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GROWTH AND YIELD RESPONSES OF MAIZE, *ZEA MAYS* L. AS INFLUENCED BY NPK 15:15:15 AND MORINGA LEAF EXTRACT IN IGBOORA, OYO STATE, NIGERIA

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ABSTRACT
A pot trial was conducted at Igboora, to evaluate the growth and yield performances of maize as influenced by Moringa leaf extract (MLE), and NPK 15:15:15 (NPK) fertilizer. MLE was extracted using standard procedures. The treatments were 25 ml foliar application of MLE at 2, 4 and 6 weeks after planting (WAP), NPK at 150 kg/ha, combined application of NPK at 75 kg/ha + MLE at 12.5 ml and control respectively. The experimental design was Completely Randomized Design (CRD) replicated 5 times. Data were collected on plant height, number of leaves, leaf area, stem diameter and yield of maize. Data were analyzed using Analysis of Variance, and significant differences were separated using Fisher's Least Significant Different (F-LSD) at $p \leq 0.05$. The result revealed that NPK (at 75 kg/ha) + MLE (at 12.5 ml) gave the highest significant plant height (202.25 cm), number of leaves (10.00), leaf area (271.71 cm^2) and yield of maize (5.71 t/ha) than other treatments and control. These are therefore, recommended for optimum growth and yield of maize in the study area.
Keywords: *Moringa leaf extract, NPK fertilizer, maize,*

INTRODUCTION
Maize (*Zea mays* L.) is ranked first in global production among grain crops (FAOSTAT, 2018). Nigeria is currently the tenth largest producer of maize in the world and the largest maize producer in Africa (IITA, 2010). *Moringa oleifera* (Moringa) is a tropical multipurpose tree and one of the most used plants in the world. However, there are limited reports on the frequency of application of the MLE and its impact on maize productivity in Nigeria. Moringa contains zeatin, a member of the plant growth hormone family known as cytokinins. These plant hormones help cell division differentiation, growth and nutrient assimilation respectively, as well as protect against oxidation (Hwang *et al*., 2012). Fajemisin (2015), reported that maize has established itself as a very significant component of the farming system, by determining the cropping pattern of predominantly peasant farmers. The maize crop requires an adequate supply of nutrients particularly nitrogen, phosphorus and potassium for optimum growth and yield. However, declining low soil fertility is the major constraint to maize production in Nigeria. Therefore, farmers will most likely embrace the use of inorganic fertilizers to augment soil nutrients and boost yield, especially with the unfortunate, inadequate availability of inorganic fertilizers or expensiveness, hence, out of reach to smaller holder farmers. Also, continuous use of inorganic fertilizer damages the soil and the environment. Thus, sustainable and environmentally friendly approaches have to be developed in the face of the negative prolong use of inorganic fertilizer on soil structure. It is based on the aforementioned that this study examined the growth and yield of maize as influenced by MLE and NPK fertilizer.

MATERIALS AND METHODS
The experiment was carried out in the screen house of Crop Production Technology Department, Oyo State College of Agriculture and Technology, Igboora, Nigeria, from July to October, 2022. Igboora is located in Ibarapa Central Local Government Area of Oyo State. The town shares boundaries with Abeokuta, Ibadan and Oke-Ogun. It is located

in the Derived Savanna Zone and has two distinct seasons (the dry season: from November to March; wet season: from April to October). The average monthly high and low temperatures are 33°C and 22°C, respectively.

Composite soil samples were collected at 0 – 20 cm depth using a soil auger. The samples were air dried, sieved with a 2 mm aperture sieve and taken to Department of Agronomy, University of Ibadan, Ibadan, Nigeria to determine their physical and chemical properties. The soil pH in H_2O (1:1) was determined with a pH meter, while available phosphorus was estimated using Bray and Kurtz (1945) method. The soil particle size was determined using the hydrometer method (Bouyoucos, 1962), while the Macro-Kjeldahl method was used to estimate total nitrogen (Jackson, 1958). The exchangeable calcium, magnesium, potassium, sodium and effective cation exchange capacity were determined using atomic absorption spectrophotometer (Tel and Hargerty, 1984).

Fresh Moringa leaves were harvested from a Moringa plantation at Igboora. The leaves were rinsed with distilled water and air dried. The dried leaves were milled and stored in sample bags. Moringa leaf powder (20 g) was added to 675 ml of ethanol in a 2.5 l, Winchester bottle and left for 24 hours (Makkar and Becker, 1996) to extract the chemicals from the leaves. The chemical composition of the leaf extract was determined at Department of Agronomy Laboratory, University of Ibadan, Ibadan, Nigeria. Oba super-1 (white variety) maize seeds were obtained from Agro-allied company in Igboora. Two maize seeds were planted at 2 cm depth into twenty experimental pots containing 8 kg soil. The seedlings were later thinned to one per pot one WAP. The four treatments (25ml of MLE, 150 kg/ha of NPK, 12.5 ml of MLE + 75 kg/ha of NPK and control),were laid out in a Completely Randomized Design, and replicated five times. A syringe was used for foliar application of MLE at 2, 4 and 6 WAP (Biswas, 2016). The application of NPK fertilizer was carried out at the standard rate of 150 kg/ha (Dugue, 2010) at 2 WAP using side dressing method. The combined application of MLE and NPK was done at 12.5 ml MLE at 2, 4 and 6 WAP + 75 kg/ha of NPK at 2 WAP as proposed by Shehu and Okafor, (2017). The untreated maize plants (control) had no application of NPK or MLE.

Data collection commenced from 3 WAP up to 13th week. A meter ruler was used to measure plant height from base to the tip of the main shoot, as well as the leaf length (L) and width (W). Leaf area (LA) was estimated using the leaf area model, $LA = 0.75LW$ (Lizaso *et al*., 2003). Number of leaves and cobs were physically counted, while the stem diameter was determined using Vernier minicalliper. Fresh shoot, fresh root and cob weights were measured using Falcon electronic scale BL 3002. All data were subjected to Analysis of Variance (ANOVA) and significant means were separated using F-LSD at 5 % level of probability.

RESULTS

Physical and chemical properties of experimental soil

The soil (table 1), on which the experiment was carried out was observed to be moderately acidic with a pH value of 6.47, low in essential plant nutrients: nitrogen (1.70 g/kg), phosphorus (9.97 mg/kg) and potassium (9.97 mg/kg), generally observed to be below the critical values of soils in the Derived Savanna Ecological Zones. The textural class was sandy loam, with 89.4 g/kg sand, 58 g/kg silt, and 48 g/kg clay.

Table 1: Physical and chemical properties of experimental soil

Elements	Values
pH (H_20)	6.47
Ca (Cmol/kg)	3.65
Mg (Cmol/kg)	0.76
K (Cmol/kg)	0.36
Na (Cmol/kg)	0.54
ECEC (Cmol/kg)	5.34
Total N (g/kg)	1.70
Total Org. C (g/kg)	8.70
Available P (mg/kg)	9.97
Particle size analysis	
Sand (g/kg)	89.4
Silt (g/kg)	58
Clay (g/kg)	48

Chemical composition of Moringa Leaf Extract

Essential plant nutrients present in the MLE were nitrogen (11.68 mg/kg), phosphorus (5.24 mg/kg) and potassium (4.20 cmol/kg). Also, some natural growth enhancers, Zeatin (4.94 mg/kg) and Giberrelin (2.80 mg/kg) were found in the MLE (Table 2).

Table 2: Chemical composition of Moringa Leaf Extract

Elements	Nitrogen (mg/kg)	Potassium (cmol/kg)	Phosphorus (mg/kg)	Zeatin (mg/kg)	Giberellins (mg/kg)
Value	11.68	4.20	5.24	4.94	2.80

Growth responses of Maize as influenced by MLE and NPK fertilizer in Igboora, Oyo State, Nigeria

The growth parameters of maize as affected by single and combined application of NPK and MLE are shown in table 3. MLE and NPK significantly ($p \leq 0.05$) enhanced height of maize. Highest significant ($p \leq 0.05$) height of maize (119.80 cm and 202.25 cm) was observed at MLE+NPK at 11 and 13 WAP, while the lowest significant plant height was observed at control (93.40 cm and 100.80 cm respectively). However, at 9 WAP, MLE+NPK produced the highest significant ($p \leq 0.05$) leaf area (271.71 cm^2), followed by NPK (230.68 cm^2), while MLE (218.70 cm^2) was not significantly ($p \leq 0.05$) different in leaf area compared to control (214.30 cm^2).

From 3 to 7 WAP, the treatments did not significantly different ($p \leq 0.05$) affect number of leaves of maize. At 11 and 13 WAP, NPK+MLE produced the highest ($p \leq 0.05$) number of leaves (12.60, 10.00), followed by NPK (11.40, 7.60) and MLE (11.20, 8.00) respectively, compared to control (9.00, 6.80). Also, highest ($p \leq 0.05$) stem diameter was observed with NPK+MLE (7.42 mm), followed by NPK (7.10 mm) and MLE (6.60 mm), while the lowest ($p \leq 0.05$) stem diameter was observed on control (6.06 mm) at 13 WAP.

Table 3: Growth responses of Maize as influenced by MLE and NPK in Igboora, Oyo State, Nigeria

			Plant height (cm)			
Treatment	3WAP	5WAP	7WAP	9WAP	11WAP	13WAP
Control	30.40	34.50	49.00	74.60	93.40	100.80
MLE	31.80	38.40	58.40	78.10	98.40	113.20
NPK	32.80	40.40	57.20	97.60	112.20	113.40
NPK+MLE	31.60	40.60	62.00	103.30	119.80	202.25
F-LSD (**0.05**)	NS	NS	NS	15.60*	17.30*	36.08*
			Leaf area (cm^2)			
Control	46.45	95.30	167.63	214.30	215.43	216.00
MLE	66.58	109.22	118.65	218.70	225.53	212.80
NPK	78.20	111.13	215.05	230.68	225.59	226.40
NPK + MLE	54.91	100.96	222.90	271.71	234.65	222.40
F-LSD (**0.05**)	NS	NS	NS	21.05*	NS	NS
			Number of leaves			
Control	3.60	5.60	8.00	10.00	9.00	6.80
MLE	3.20	5.40	7.60	9.80	11.20	8.00
NPK	3.60	6.00	9.60	10.20	11.40	7.60
NPK + MLE	3.00	6.20	7.80	9.60	12.60	10.00
F-LSD (**0.05**)	NS	NS	NS	NS	2.10*	1.95*
			Stem diameter (mm)			
Control	2.00	2.90	3.82	5.12	4.90	6.06
MLE	1.86	3.34	4.32	5.70	5.70	6.60
NPK	3.20	3.76	4.80	6.24	6.30	7.10
NPK+MLE	2.90	4.00	5.20	6.30	6.76	7.42
F-LSD (**0.05**)	0.80*	0.80*	0.89*	0.80*	1.03*	0.74*

Yield responses of Maize plants as influenced by MLE and NPK in Igboora, Oyo State, Nigeria

The yield responses of maize plants to single and combined application of NPK and MLE are shown in table 4. The application of NPK+MLE produced 1.40 cobs, but was not significantly higher ($p \leq 0.05$) than other treatments. The highest ($p \leq 0.05$) yield of cobs was produced by NPK+MLE (5.71 t/ha) as compared to NPK (3.57 t/ha), MLE (2.26 t/ha) and the control (2.16 t/ha). Also, NPK+MLE produced the highest ($p \leq 0.05$) fresh shoot weight (102.08 g), compared to control (20.26g) and MLE (71.00 g), but not significantly higher ($p \leq 0.05$) than NPK (82.02 g). Also, NPK+MLE produced the highest ($p \leq 0.05$) fresh root weight (36.40 g), compared to control (9.06 g) and MLE (25.08 g), but not significantly different ($p \leq 0.05$) from the NPK (29.48 g).

Table 4: Yield responses of maize plants as influenced by MLE and NPK at Igboora, Oyo State, Nigeria

Treatment	Number of cobs	Yield of cobs (t/ha)	Fresh Shoot weight (g)	Fresh Root Weight (g)
Control	1.00	2.16	20.26	9.06
MLE	1.20	2.26	71.00	25.08
NPK	1.40	3.57	82.02	29.48
NPK+MLE	1.40	5.71	102.08	36.40
LSD	NS	1.13*	28.90*	10.50*

DISCUSSION

The single application of NPK, MLE and combined application which enhanced some of the growth and yield attributes of maize (height, leaf area and number of leaves), agree with Chattha *et al*. (2015), who reported that application of MLE enhanced the growth rate, number of leaves plant height, shoot and root fresh weight and dry weight of shoot, root of maize. The significant increase in growth and yield of maize treated with the combined application of MLE at 25 ml and NPK at 75 kg/ha was attributed to the high level of essential macro nutrient (nitrogen, phosphorus, potassium), present in the inorganic fertilizer and in the MLE due to presence of zeatin and gibberellin which are growth enhancers. Nitrogen, phosphorus, potassium, and other nutrient elements play great physiological importance in formation of chlorophyll, nucleotides, enzymes, hormones and vitamins for optimum grain yield Mohamed *et al*. (2008). Also, Khan (2008) reported that phosphorus is essential for maize growth, and plays a vital role in grain production.

CONCLUSION AND RECOMMENDATION

Based on the results of this study, it is concluded that NPK and MLE enhanced the growth and yield of maize, therefore, may be used to boost growth and yield of maize. Combined application of NPK at 75 kg/ha + MLE at 12.5ml gave the highest growth and yield parameters of maize. The high level of nitrogen, phosphorous, potassium, zeatin and gibberellin present in the MLE are generally assumed to be responsible for the enhanced growth and yield of maize, complimented by zeatin and gibberellin which are growth enhancers present in the MLE. Moringa leaf in combination with NPK fertilizer is therefore, recommended for use by maize farmer for optimum growth and yield of maize.

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SUITABILITY OF CONTACT HERBICIDES FOR MAIZE PRODUCTION UNDER ZERO TILLAGE ON *TITHONIA DIVERSIFOLIA* INFESTED SOIL

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ABSTRACT
Evaluation of selected herbicides for user in zero-tilled maize production field experiment was conducted at Ogbomoso farm settlement in Oyo State. The treatments were laid out in a Randomized Complete Block Design (RCBD) with three replicates. The treatments consisted of paraquat at 1.5.0 a.i/ha, glyphosate at 3.0 a.i/ha, fusilade at 1.0 a.i/ha 2,4-D amine at 3.0 a.i/ha and hoe weeding. The herbicides were applied using Knapsack sprayer which was caliberated to deliver at 200 litres/ha. Application of the herbicides was done one week after slashing, when the cut weeds has resumed active regrowing. Result showed that paraquat and glyphosate herbicides had no significant effect on the germination of maize. The highest germination occurred under paraquat (100%) and glyphosate (100%) while the least occurred under Fusilade (58.7%). The highest yield per plant of maize was recorded under paraquat and glyphosate (36g and 30g) respectively while the least was obtained under fusilade (23g). This implies that both paraquat and glyphosate has very good weed control efficiency, here they are the most suitable for zero tilled maize. While 2,4 D amine had a very good control efficiency in terms of the weed population and biomass both at four (4) weeks after sowing and at flowering, the growth and yield performance of maize was hampered possibly due to the phytotoxicity of the herbicide. Fusilade was not able to control the weeds effectively due to fact that majority of the weeds on the plot were dicots. Fusilade is indicated for the control of grass weeds.

INTRODUCTION
Maize (*Zea mays* L.) is a member of the grass family (Graminae). It originated from South and central American Okoroafor *et al.*, 2013. It was introduced to West Africa by the Portuguese in the 10th century. Maize is one of the most important grains in Nigeria, not only on the basis of the number of farmers that engaged in its cultivation, but also in its economic value. Maize is a major important cereal being cultivated in the rainforest and the derived savannah zones of Nigeria. Maize has been in the diet of Nigerians for centuries. It started as a subsistence crop and has gradually become a more important crop. Maize has now risen to a commercial crop on which many agro-based industries depend for raw materials (Iken and Amusa, 2004). Maize is the most important cereal in the world after wheat and rice with regard to cultivation areas and total production (Purseglove, 1992; Osagie and Eka, 1998). According to Khawar *et al*. (2007), maize has a variety of uses. Its grain is a rich source of starch, vitamins, proteins and minerals. Studies in maize production in different parts of Nigeria have shown and increasing importance of the crop amidst growing utilization by food processing industries and livestock feed mills (Ogunsumi *et al*., 2005; Khawar *et al*., 2007; Abaduhaman and Kolawole, 2008). The crop has thus grown to be a local ''cash crop'' most especially in the southwest part of Nigeria where at least 30 percent of the cropland has been put to maize production under various cropping system (Ayeni, 1991; Degrande and Danjuma, 2000).
Zero tillage also known as no-till farming refers to a cultivation that leaves fields unturned and allow crop stubble to remain on the soil surface from harvesting to sowing. The stubble protects the soil surface. Experimental studies have confirm that no-till farming markedly reduces erosion, nitrogen runoff and particulate phosphorus runoff (Soileau *et al*., 1994, Stonedhouse 1997). These findings have prompted interest in no-till as a cultivation technology that would benefit both farmers and the environment. However, no-till has been linked to undesirable environmental effects, in

particular increased loading of dissolved reactive phosphorus (Holland 2004, Puustinen *et al*., 2005) and leaching of herbicides due to increased herbicide application (Holland, 2004, Rose and Carter, 2003). The use of contact herbicides is very paramount in no-till due to the need for the elimination of the weed without turning the soil. Contact herbicides kill only the parts of the plants they touch by moving quickly into the shoots, the roots, the leaves, rhizomes, stolon and growing point of the treated plants. Therefore, uniform spray coverage and particle size are essential for adequate control. Contact herbicides do not kill perennial underground structure such as tubers and bulbs. Repeat applications to re-growth may eventually drain the plants underground resources. Examples of herbicides are glyphosate, paraquat and 2, 4-D.

Tithonia diversifolia commonly known as Mexican sunflower, is an annual, aggressive leafy weed shrub commonly found in many parts of the world. It grows to a height of 0.3m or more and it is adaptable to most soils (Jama *et al*., 2000; Olabode *et al*., 2007). In the south-western Nigeria, the weed had predominantly suppressed many common weeds including *Chomolaena odorata*, grassy weeds including *Imperata cylindrical* and many crop-plants such as maize plant, in competition (Jama *et al*., 2000; Nziguheba *et al*., 2002; Olabode *et al*., 2007; Chukwuka and Omotayo, 2008) The aggressive nature and high growth rate of Mexican sunflower has been attributed to its possible allelopathic effects on the neighbouring weed seeds, crop-plants and the smothering effects on their seedlings (Baruah *et al*., 1994; Boureima *et al*., 2007). Mexican sunflower possess both fertilizer attributes as well as phytotoxic growth inhibiting (Baruah *et al*., 1994; Ayeni *et al*., 1997).

MATERIALS AND METHODS

The field experiment was conducted at Ogbomoso farm settlement in Oyo State. The five treatments were laid out in a Randomized Complete Block Design (RCBD) with three replicates. The treatments consisted of paraquat at 1.5. a.i/ha, glyphosate at 3.0 a.i/ha, Fusilade at 1.0 a.i/ha 2,4-D amine at 3.0 a.i/ha and hoe weeding. The size of the experimental plot is 19m by 8m with three replicates. Each plot was separated with an alley 1m between the replicates and plots.The application was done using the knapsack sprayer which was calibrated to deliver at 200 litres/ha. The experimental plot was slashed and the debris removed to allow the herbicides have a direct contact with the weeds regrowth. Application of the herbicides was done one week after slashing and packing was done to allow the cut weeds to resume active regrow. The herbicides were applied at the recommended rates. Glyphosate was applied at 3 litres/ha, Fusilade at 1litres/ha, paraquat at 1.5 litres/ha and 2,4-D amine at 3litres/ha. Maize variety, OBA SUPER was obtained from farmers shopping centre in Ogbomoso, and was planted after packing of debris and after spraying. Thinning was done 2 WAS to reduce the plant to two plants per stand. The post emergence application of atrazine was done at 3 WAS at the rate of 5 litres/ha. This was done when there was appearance of undergrowth following the killing of the established weeds.

RESULTS AND DISCUSSION

The effect of selected herbicides on the germination of maize was presented in Table 1. The highest germination percentage were recorded under paraquat (100%) and glyphosate (100%), followed by 2, 4-D amine (98.7%). There were no significant differences between these treatments ($p \leq 0.05$) on the germination percentage. However, hoe weeding treatment recorded 85% of germination when compared with the herbicide treatments but more effective than fusilade (58.7%) for percentage germination. The effect of the herbicides on maize stem diameter is also presented in table 1. Glyphosate has the highest value (1.1cm) followed by paraquat (0.8cm), hoe weeding (0.8cm) and 2,4-D amine (0.7cm). Fusilade produced the thinnest stem diameter (0.5cm). There were no significant difference between the treatments and control with respect to leaf area at flowering, plant height at 4 WAS.

Table 1: Effect of Selected Herbicides on Growth Parameters of Maize

Treatments	%Emergence	%Survival	Stem diameter at 4WAS (cm)	Stem diameter at flowering (cm)	Plant height at 4WAS (cm)	Plant height at flowering (cm)	Leaf area at flowering (cm)
Paraquat	100a	98.7a	0.8b	2.9a	70.1a	176.0ab	710.3a
Glyphosate	100a	100a	1.1a	2.5a	75.5a	188.5a	835a
Fusilade	58.7c	30.7c	0.5c	2.8a	63.2a	157.7c	693a
2,4-D amine	98.7a	97.3a	0.7bc	2.7a	58.6a	165.3bc	651.7a
Hoe weeding	85b	83.3b	0.8b	3a	64a	185a	747.7a

Means followed by the same superscript are not significantly different by DMRT ($p \leq 0.05$)

At flowering however, glyphosate produced significantly taller plants (188.5cm) which was comparable to hoe weeding (185.0cm) and paraquat (176.0cm). Fusilade produced the shortest plant (157.7cm) at flowering.

Table 2 present the effect of selected herbicides on the yield parameters of maize. There were no significant differences among the treatments with respect to number of days to flowering and number of cobs per plant. The earliest maize tasselling was recorded under glyphosate (53 WAS) while the late to tasseled was recorded under 2,4-D amine (60.7 WAS). The highest number of grain per cob was recorded under the control (310.3) and this is not significantly different to 265.5 grains produced by glyphosate (Table 2). The least number of grains per cob was recorded under paraquat (130.8), but was not significantly different from 2,4-D (174.7) and fusilade (166.7). The highest weight of

100 seeds (36g) was obtained under paraquat which is significantly superior to glyphosate (30g) and hoe weeding (25.7g). Fusilade and 2,4-D amine produced the lightest seeds (23g and 24g respectively).

Table 2: Effect of selected herbicides on the yield parameters of maize

Treatments	Days to flowering	No of grain per cob	No of cob per plant	Weight of 100 seeds(g)
Paraquat	56.7a	130.8b	1.5a	36a
Glyphosate	53a	265.5a	1.3a	30b
Fusilade	56a	166.7b	1.0a	23c
2,4-D amine	60.7a	174.7b	a.2a	24c
Hoe weeding	54a	310.3a	1.2a	25.7bc

Means followed by the same superscript are not significantly different by DMRT ($p \leq 0.05$)

Table 3 presents the weed density of selected herbicides on maize plot. The weed population was calculated by Quadrat method. A 25 cm by 25cm Quadrat was used for sampling. At 4 WAS, the treatment show no significant differences for weed population and weed biomass. At flowering however, fusilade has the highest weed biomass (112.3g) which is significantly different from paraquat (82.7g). Glyphosate and hoe-weeded control show no significant differences with 56.3g and 56.5g respectively. 2,4-D amine recorded the lowest biomass of 44.8g. At flowering, fusilade recorded the highest population of weeds (28 m^{-2}) which is significantly different from glyphosate and control that recorded 17.5 m^{-2} and 16 m^{-2} of weeds respectively both of which are only comparable to paraquat that recorded 10.6 m^{-2} of weeds and 2,4-D amine that recorded 13 m^{-2}. 2,4-D amine has the lowest weed population and weed biomass. Fusilade was the poorest as it recorded the highest weed population and highest weed biomass, respectively.

Table 3: Weed density of selected herbicides on maize plot

Treatments	Weed biomass at 4WAS(g)	Weed population at 4WAS	Weed Biomass at flowering (g)	Weed population at flowering
Paraquat	9.3a	6.3a	82.7b	10.6c
Glyphosate	7.5a	7.5a	56.3c	17.5b
Fusilade	20.3a	10.7a	112.3a	28a
2,4-D amine	5.7a	5.7a	44.8d	13bc
Hoe weeding	19a	10.7a	56.5c	16b

Means followed by the same superscript are not significantly different by DMRT ($p \leq 0.05$)

CONCLUSION AND RECOMMENDATION

From the result, glyphosate and paraquat had the best result in terms of maize growth and yield parameters. This may be due to effective weed control efficiency. The growth and yield performance of maize was hampered possibly due to the phytotoxicity of the herbicide. For Fusilade, it was not able to control the weed effectively possible due to the fact that majority of the weeds on the plot were dicots. Fusilade is indicated for the control of grass weeds. From the above, it could be concluded that both glyphosate and paraquat could be used effectively for weed control on zero-tilled maize plots.

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EFFECT OF PLANT SPACING ON GROWTH AND GRAIN YIELD OF COWPEA (*VIGNA UNGUICULATA* (L.) WALP.).

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ABSTRACT
Yields of cowpea have been reported to be low due to inappropriate spacing of genotypes with different maturity periods. Therefore, this study was conducted to assess the effect of plant spacing on growth and grain yield of two cowpea varieties (Oloyin and Seyin). The two varieties associated with contrasting maturity dates were sown under three different intra-row spacings (60 cm x 30 cm, 60 cm x 40 cm and 75 cm x 30 cm). The experiment had 18 plots with 1.5 x 1 m plot size. The results showed that variety 1 (Oloyin) was significantly different ($p \leq 0.05$) with respect to number of days to flowering and plant height, while 60 cm x 30 cm plant spacing was observed to be significantly higher ($p \leq 0.05$) with respect to weight of 100 grain and grain yield as compared to other plant spacing. Therefore, variety 1 (Oloyin) is recommended for the farmers at planting spacing of 60 cm x 30 cm.

INTRODUCTION
Cowpea (*Vigna unguiculata* (L.) Walp) is of major importance to the livelihoods of millions of people in the developing countries of the tropics (Singh *et al*., 1997). Cowpea provides essential protein requirements in human diet. It is reported to contain the highest (23-25 %), protein (Singh *et al*., 1997). Like other legumes, cowpea fixes atmospheric nitrogen (N) through Biological Nitrogen Fixation (BNF), a symbiotic association between soil dwelling bacteria, commonly known as rhizobia, and legume host plants. This symbiosis results in nitrogen replenishment as evidenced in many experimental findings that have illustrated increasing soil N levels following cowpea cultivation (Thies *et al*., 1995).

The total area harvested with cowpea worldwide is about 10, 979 841 ha. As a result, annual world cowpea seed production is 364, 817 tonnes (FAO, 2010). West and central Africa are reported to be the leading cowpea producing regions in the world, accountable for 64 % of the annual estimation of 3 million tonnes of cowpea (IITA, 2009). Nigeria is the leading cowpea producer in Africa responsible for 68 %, followed by Ghana, Niger, Senegal and Cameroon (IITA, 2009). Subsistence farmers in the semi-arid and sub-humid regions of Africa are the major producers and consumers of cowpea. These farmers not only grow cowpeas for dry seed, but also utilize the leaves and pods as vegetables (IITA, 2009). Fresh tender leaves, immature pods and fresh peas are consumed as vegetables, while several snacks and main dishes are prepared from the dry grain. All plant parts that are used for food have been found to be nutritious, providing protein, vitamins and minerals. The other plant parts, besides dry seeds, are commonly consumed as young leaves, immature pods and immature seeds (IITA, 2009).

The price of cowpea especially Oloyin is becoming exorbitant and unaffordable to an average man, hence, the need to examine if the other local varieties may be a used as substitutes. Also, plant spacing is an important factor in crop production as an efficient way to optimise space and as well, reduce competition among plants with similar cultural requirements, while simultaneously enhancing nutrient composition of the soil. Also, without promoting pests, or providing shade, but strengthening the microclimate (wind, moisture, and improves the interaction of beneficial microorganisms within the soil's rhizosphere), (Nnoke, 2001; Godasu and Rajkumar, 2021). The objective of the study was therefore, to evaluate the effect of spacing on growth and grain yield of 2 varieties of cowpea (*Vigna unguiculata* (L.Walp) at 3 different plant spacings.

MATERIALS AND METHODS

The research was conducted at the Teaching and Research Farm, Oyo State College of Agriculture and Technology, Igboora, located in the rainforest vegetation zone of South-Western Nigeria.The two cowpea varieties (Oloyin and Seyin) used for the study were purchased from Towobowo market, Igboora and Anko market, Eruwa respectively. The experiment was carried out during the late wet season (September, 2022). The land used for the study was cleared and ploughed mechanically with the use of tractor. Subsequent field activities were done manually by weeding, hoeing and use of a cutlass. The experimental site measured 8.5 m by 6 m, with sub-plots of 2 m x 1.5 m. Three spacings were used; 60 cm x 30 cm, 60 cm x 40 cm, 75 cm x 30 cm, with two plant rows per plot. Spacing 1 had 10 stands, spacing 2 had 8 stands, while spacing 3 had 10 stands. The treatments were arranged as a split-plot in a Randomized Complete Block Design (RCBD) with three replications, totalling of 18 plots. The following agronomic data were collected on 5 randomly selected plants per plot: Days to flowering, plant height at flowering, number of peduncles per plant, length of peduncle per plant, length of pod, number of days to 90 % maturity, number of grains per pod, weight of 100 cowpea grains and grain yield per plot. Data were subjected to analysis of variance (ANOVA) and significant means were separated using Duncan's Multiple Rang Test (DMRT) at 5 % level of probability.

RESULTS AND DISCUSSION

Mean performance of 2 varieties of Cowpea at three planting distances

The highest ($p \leq 0.05$) grain weight (16.49 g) was observed in variety 1 (Oloyin) at the spacing of 60 cm x 30 cm, while the lowest ($p \leq 0.05$) grain weight (5.29 g) was recorded in variety 2 (Seyin) at the spacing of 75 cm x 30 cm. The highest ($p \leq 0.05$) grain yield (16.47 g) was observed in *Oloyin* at th spacing of 60 cm x 30 cm, while the lowest ($p \leq 0.05$) grain yield (5.29 g) was observed in *Seyin* at the spacing of of 75 cm x 30 cm. *Oloyin* flowered earlier (48 days) while Seyin flowered later (50 days after planting). also, Oloyin was observed to have the highest($p \leq 0.05$) plant height (21.67 cm) at 75 cm x 30 cm while *Seyin* had the lowest ($p \leq 0.05$) plant height (13.67 cm) at 60 cm x 30 cm spacing.

Mean performance of 2 varieties of Cowpea at three planting distances

The highest ($p \leq 0.05$) number of peduncle (5.93) was observed with Seyin at 60 cm x 40 cm spacing, while the lowest ($p \leq 0.05$) number of peduncles 3.63 was recorded at 75 cm x 30 cm spacing. Variety 1 (Oloyin) recorded the highest ($p \leq 0.05$) pod length (9.93 cm) at 60 cm x 30 cm spacing, while the lowest ($p \leq 0.05$) pod length (8.60 cm) was observed at on Seyin at 60 cm x 40 cm spacing. The highest ($p \leq 0.05$) number of pod (5.93) was observed at variety 2 (Seyin) at 60 cm x 40 cm spacing, while least ($p \leq 0.05$) number of pod (3.63) was observed at 75 cm x 30 cm spacing. Also, the highest l($p \leq 0.05$) ength of peduncle (25.67 cm) was observed in variety 2 (Seyin*)* at 60 cm x 40 cm spacing, while lowest($p \leq 0.05$) length of peduncle (13.67 cm) was recorded on variety 1 (Oloyin) with planting distance of 75 cm x 30 cm. The highest number of grains (6.23) was observed at variety 1 (*Oloyin*) at of 60 cm x 40 cm while variety 2 (Seyin) recorded the lowest ($p \leq 0.05$) number of grains (4.27) at 75 cm x 30 cm. *Oloyin* had the least number of days to maturity (61.33) with planting distance of 60 cm x 30 cm while Seyin had the highest ($p \leq 0.05$) number of days to maturity (63.00) at of 60 cm x 40 cm spacing.

Table 1: Performance of 2 varieties of Cowpea at three planting distances

CHARACTER	VARIETY	PLANT 60 x 30 cm	DISTANCE 60 x 40 cm	75 x 30 cm	
Weight of 100 grains	Oloyin	16.49	7.32	7.48	NS
	Seyin	13.96	9.97	5.29	NS
		15.23a	8.65ab	6.38b	
Grain yield /plot	Oloyin	16.47	7.32	7.48	NS
	Seyin	13.96	9.97	5.29	NS
		15.22a	8.64ab	6.38b	
	Seyin	4.93	5.93	3.63	
		NS	NS	NS	
Days to flowering	Oloyin	48.33	48.00	48.33	48.22b
	Seyin	50.67	51.00	51.00	50.89a
		NS	NS	NS	
Plant height	Oloyin	20.67	21.00	21.67	21.11a
	Seyin	13.67	14.67	14.00	14.11b
		NS	NS	NS	
Number of peduncles	Oloyin	5.00	4.20	4.80	
	Seyin	4.93	5.93	3.63	
Length of pod	Oloyin	9.93	9.88	9.00	

	Seyin	9.67	8.60	9.13
		NS	NS	NS
Number of pods	Oloyin	5.00	4.20	4.80
	Seyin	4.93	5.93	3.63
Length of peduncle	Oloyin	20.00	14.20	13.67
	Seyin	25.53	25.67	20.60
		NS	NS	NS
Number of grains	Oloyin	5.60	6.23	4.80
	Seyin	5.13	4.67	4.27
		NS	NS	NS
Days to maturity	Oloyin	61.33	62.00	61.67
	Seyin	62.00	63.00	62.00
		NS	NS	NS

Means followed by the same letters in a column are not significantly ($p \leq 0.05$) different; NS: Not Significant

CONCLUSIONS AND RECOMMENDATION

The study showed that Oloyin flowered earlier than Seyin attributed to earlier initiation of flowering in Oloyin and consequently, ripening and early pod rupturing and seed maturity. Also, the study showed that Oloyin produced higher yield which will be of greater advantage to farmers. Oloyin is therefore recommended to the farmers in the study area to at 60 cm x 30 cm spacing.

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ROOT YIELD AND NUTRITIONAL COMPOSITION OF ORANGE FLESH SWEETPOTATO WITH NPK FERTILIZER IN ANYIGBA, NIGERIA

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ABSTRACT

*This experiment was conducted in 2021 cropping season at Anyigba (latitude 7˚28′ N, longitude 7˚10′ E) in the southern guinea savannah agro ecological zone of Nigeria to determine root yield and nutritional composition of two varieties of orange flesh sweetpotato UmuSPO 1, UmuSPO 3 with NPK fertilizer. . The experiment was laid out in a randomized complete block design with three replications. The plot size was 2m x 3m and planting distance of OFSP varieties were 1m x 0.30m. Sweetpotato roots (t/ha) were harvested at 16 weeks after planting. Nutritional composition analyses of the two varieties of OFSP were determined using the standard procedure of Association of Official Analytical Chemists. The results obtained showed that 400kg/ha of NPK 15:15:15 fertilizer gave the highest root yield irrespective of variety. However, there were significant differences in the proximate composition (%) of the varieties. UmuSPO 1 recorded the higher fat content (0.7±0.15), protein (6.5±0.00) and carbohydrate content (25.35±0.12) while UmuSPO 3 recorded the higher moisture (6.50±0.01), ash (3.04±0.02) and crude fibre (1.72±0.02). Mineral composition (mg/kg) UmuSPO 1 had the higher Ca (68.39±1.0), Na (33.64±0.11), K (51.10±1.14) and Mg (18.17±0.0) while UmuSPO 3 had higher Fe (11.18±0.10) and P (110±20.0). For vitamin composition UmuSPO 3 recorded the higher Beta-carotene (*μg/100g*) (2473±1.16), vitamin A (158.4±1.10* μg/RE)*) and vitamin C (14.12±0.01mg/100g).*

Keywords: *Orange flesh sweetpotato, NPK fertilizer, root yield, nutritional composition*

INTRODUCTION

Sweet potato (*Ipomoea batatas*) is a dicotyledonous plant that belongs to the family convlvulacea. The crop is grown in many countries globally, but production primarily occurs in tropical and subtropical areas where it is an important staple food in the diet of many people. It is one of the most important root crops in sub-Saharan Africa with both domestic and industrial uses and its nutritional value far exceed that of yam, cocoyam and cassava (Nmor and Okobia, 2017). Orange flesh sweetpotato has been reported to increase children's levels of vitamin A and serum retinol concentration and has been used to fight global vitamin A deficiency (Islam *et al*., 2016).

Low soil fertility has been recognized as one of the major production constraints affecting agriculture. Soil fertility depletion in small holder farms is the fundamental issue (Sanchez *et al.,* 1996). This depletion is mainly due to intensive and continuous cropping with low application of nutrients. The low and declining productivity of many tropical soils are the major constraints limiting the realization of the improved genetic potential of crop that is now available. As poor soil fertility limits the realization of the genetic potential of the crop, fertilization of the sweetpotato crop becomes inevitable.

Fertilizers are known to have significant influence on vegetative growth of crops and subsequently increased in root yield (Toungos, 2016). The three major fertilizer elements known to be deficient in most Nigerian soils due to intense pressure on land because of continuous cropping are Nitrogen (N), Phosphorous (P) and Potassium (K) (Toungos, 2017). Fertilizers, especially NPK, promote vegetative growth and impart deep green colour characteristics essentially for photosynthesis. Research has shown that application of inorganic fertilizer increases root yield (Okpara *et al.*, 2011)) Research reports on sweetpotato response to fertilizer in Nigeria has been on the white fleshed type while little is known about nutrient management for orange-fleshed sweet potato. The present study examined the response of two varieties orange-fleshed sweetpotato (UmuSPO 1, UmuSPO 3) to the nutrient management strategy involving NPK 15:15:15. However, there is dearth of information on the magnitude effects on root yield and yield components of orange flesh sweetpotato genotypes in soils of Kogi state. The objective of the study was to determine root yield and nutritional composition of orange flesh sweetpotato with NPK 15:15:15 fertilizer in Anyigba, Kogi State Nigeria

MATERIALS AND METHODS

The experiment was conducted at the botanical garden of Prince Abubakar Audu University, Anyigba Kogi State in the Faculty of Natural Sciences of the University. Anyigba is located on latitude 7˚28ʹ N and longitude 7˚10ʹ E in the Eastern part of Kogi state in the DenikaLocal Government Area of Kogi State. The experiment was laid out in a randomized complete block design (RCBD) with three replications. The experimental treatments were two varieties of orange flesh of sweetpotato (UmuuSPO 1 and UmuSPO 3) and 4 levels of fertilizer (0, 200, 400 and 600).The clearing of the site was done manually with machete and hoe. Ridges were done manually using hoe. The planting distance was 1m x 0.30 and length of vine was 30 cm which may contain 3 - 4 nodes. Two varieties of orange flesh sweetpotato vines were collected from National Root Crops Research Institute, Umudike. The healthy vines of OFSPO UmuSPO 1and UmuSPO 3 were planted at the botanical garden ofPlant Science and Biotechnology Department and the planting depth was 5 – 10 cm. The planting was done on 01/08/2021 and good agronomic practices were carried out. Roots were harvested at 16 weeks after planting and (WAP) measurements were taken on number of roots per plant, weight of roots/plant (g) and weight of root/ ha which was subjected to analysis of variance using Genstat discovery 1 edition. Tthe proximate composition (%) of the OFSP varieties (moisture, ash, crude protein, crude fat, crude fibre) were determined according to the method of AOAC (2012) and total carbohydrate was calculated by Atwater factor..

RESULTS AND DISCUSSION

The effect of NPK 15:15:15 fertilizer on two varieties of orange flesh sweetpotato showed that irrespective of fertilizer levels used there is no difference on the number of roots. (Table 1 and Table 2) UmuSPO 3 gave the highest root yield and 400Kg/ha of NPK 15:15:15 fertilizer gave the highest root yield across followed by 600Kg/ha while 0Kg/ha gave the lowest root yield. Yield is an important component of any crop and means of increasing yield is through good agronomic practices which fertilizer application is one of them. Application of fertilizer increases the number of roots in respective of the variety. According to Okpara *et al*., (2011) confirmed that application of NPK 15:15:15 fertilizer increased root yield of sweetpotato.

The results of the effects of NPK 15:15:15 on the proximate composition of two varieties of OFSP showed that there was a difference ($P<0.05$) for all the proximate composition % (moisture, ash, crude protein, crude fat, crude fibre and carbohydrate) analyzed (Table 3). UmuSPO 1 had the highest fat content (0.7 ± 0.15), (protein 6.5 ± 0.00)) and carbohydrate content while UmuSPO 3 obtained the highest moisture (24.35 ± 0.12), ash and (crude fibre (3.04 ± 0.02). There were differences in moisture content of two varieties OFSP which could be a result of genetic composition (Wenkam, 2008). Crude protein content was higher in UmuSPO 1 variety compared to UmuSPO 3. Sweetpotato could serve as an excellent source of protein in diet if consumed regularly. Protein provides essential amino acids to the body, and protein content in food varies widely (Senannayake et al., 2013). Sweetpotato has low fat content, the result obtained for low fat content (0.2% and 0.17%) were similar to work of Tumuhimbise *et al*., (2013). The ash content of UmuSPO 3 was higher but UmuSPO 1 the ash content was low. The ash content refers to complete oxidation of organic matter in the sample which gives an overview of the mineral content of the material (Agbede and Adekiya, 2011). UmuSPO 3 was likely to be better source of nutrient in the diet as compared to UmuSPO 1. Nutritionally, ash aids in the metabolism of protein, carbohydrate and fat. (Abbasi *et al*., 2011). Carbohydrate content is higher in UmuSPO 1than in UmuSPO 3 and carbohydrate provides energy to cells in the body, particularly the brain, the only carbohydrate dependent organ in the body (Islam *et al*., 2016). Orange flesh sweetpotato could be supplementary for carbohydrate need in the diet.

The results of the effects of NPK 15:15:15 on the mineral composition of two varieties of OFSP (Table 4).There was a significant difference ($P<0.05$) for mineral contents (mg/kg) (Ca, Na, K, Mg Fe and P) analysed. UmSPO 1 variety obtained the highest Ca (68.39 ± 1.0), Na (33.64 ± 0.11), K (±51) and Mg (18.17 ± 0.00) while UmuSPO 3 variety recorded the highest Fe (11.18 ± 0.10) and P (110 ± 20.0). The results of the effects of NPK 15:15:15 on the vitamins composition of two varieties of OFSP (Table 5). There was a significant difference ($P<0.05$) for all the vitamin constituents ($\mu g/100g$) (B carotene2473 $\pm$ 1.16), Vitamin A (158.4 ± 1.10) and Vitamin C constituents $\mu g/RE$)(14.12 ± 0.01). UmuSPO 3 contains higher vitamin A and C while UmuSPO 1 had the least content. Vitamins are generally needed in small amount from foods. They yield no energy directly but may contribute to energy yielding chemical reactions in the body and promote growth and development (Islam *et al*., 2016). Vitamin C is mainly used in synthesizing collagen, a major protein for connectives tissues. It is generally antioxidant, enhances iron absorption and is needed for synthesizing some hormones and neutron transmitters.

CONCLUSION

NPK 15:15:15 fertilizer increased root yield and yield component of root yield of two varieties of OFSP. The nutritional compositions of the two varieties of OFSP were enhanced by fertilizer application. Carbohydrate content is higher in UmuSPO 1than in UmuSpo 3 and UmuSPO 3 contains higher vitamin A and C while UmuSPO 1and the least content. This study further confirmed that application of fertilizer to crops is necessary for improvement in root yield.

RECOMMENDATION

Application of 400Kg/ha of NPK 15:15:15 fertilizer is recorded for production of root yield and yield component of OFSP varieties. Fertilizer contributed to increase in root yield of OFSP. And OFSP should be consumed for good health as it contains high quantity of Beta-carotene and vitamins

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Table 1: Effect of fertilizer NPK 15:15:15 on number of roots/plant, root weight /plant and root weight (t/ha)

	Number of roots/plant	Root weight/plant (g)	Root weight (t/h)
Variety			
UmuSPO 1	1	191.2	6.4
UmuSPO 3	2	228.6	7.6
LSD	**ns**	**Ns**	**ns**
Fertilizer			
0	2	110.2	4.0
200	1	202.2	6.7
400	2	300.0	10.0
600	2	227.2	7.3
		***	***
LSD	**ns**	**67.7**	**2.0**

Table 2: Interaction Effect

		Number of Roots/plant	Root weight/Plant (g)	Root weight/ (t/h)
Variety X Fertilizer				
UmuSPO1	0	1	77.1	3.2
UmuSPO1	200	1	191.7	6.4
UmuSPO 1	400	1	283.3	9.4
UmuSPO 1	600	2	212.7	6.5
UmuSPO 3	0	2	143.3	4.8
UmuSPO 3	200	1	212.7	7.1
UmuSPO 3	400	2	316.7	10.6
UmuSPO 3	600	2	241.7	8.1
LSD		**ns**	**117.31**	**3.46**

Table 3: Effect of NPK fertilizer 15:15:15 on proximate composition of two varieties of orange flesh sweetpotato.

Constituents (%)	Variety	
	UmuSPO 1	**UmuSPO 3**
Moisture	64.58 ±0.11b	65.27±0.01a
Ash	2.92 ± 0.10b	3.04 ± 0.02a
Crude fibre	1.63±01b	1.72± 0.02a
Fat	0.72 ± 0.15a	0.65 ± 0.02b
Protein	6.50± 0.00 a	5.70 ± 0.01b
Carbohydrate	25.35±0.12a	23.73± 0.04b

Table 4: Effect of NPK fertilizer 15:15:15 on mineral composition of two varieties of orange flesh sweetpotato.

Variety	Ca (mg/kg)	Na (mg/kg)	K (mg/kg)	Mg (mg/kg)	Fe (mg/kg)	P (mg/kg)
UmuSPO 1	68.39 ±1.00a	33.64 ±0.11a	51.10 ±1.14a	18.17 ±0.00a	11.18 ±0.10b	110 ±20.0b
UmuSPO 3	59.31 ±0.02b	30.05 ±0.02b	44.83 ±0.06b	17.02 ±0.03	`13.45 ±0.05a	143 ±34.0a

Table 5: Effect of NPK fertilizer 15:15:15 on vitamin composition of two varieties of orange flesh sweetpotato.

Varieties	ß- Carotene (µg/RE)100g	Vitamin A(µg/RE)100g	Vitamin C(µg/RE)
UmuSPO 1	1768±0.22b	149.64 ±1.31b	13.04±0.24b
UmuSPO 3	2473±1.16a	188.42±1.10 a	114.1±0.00a

GROWTH AND YIELD OF OKRA (*ABELMOSCUS ESCULENTUS* L.) AS INFLUENCED BY DIFFERENT LEVELS OF POULTRY DROPPINGS AND COW DUNG UNDER IRRIGATION IN LAFIA, SOUTHERN GUINEA SAVANNA

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ABSTRACT
Pot experiment was conducted at the Screen House of Faculty of Agriculture Shabu-Lafia Campus, Nasarawa State University, Keffi, to determine the effect of different levels of poultry droppings and cow dung on growth and yield of okra. The experiment consisted of 4 × 4 factorial combination of four levels each of poultry droppings (0, 10, 15 and 20 tons/ha) and cow dung (0, 20, 30 and 40 tons/ha) and arranged in Completely Randomized Design (CRD) with three replications. The results obtained showed that application of 15 t/ha of poultry droppings produced significantly the tallest plants, more number of leaves, number of capsules per plant, capsules length, fresh and dry weights of capsules and green capsules yield against any other levels of poultry applied droppings. The results also revealed that application of 30 and 40 t/ha of cow dung recorded the greatest values in all the variables measured in this study. From the study it was observed that 15 t/ha of poultry droppings enhanced the vegetative growth of okra (i.e. plant height, number of leaves) while 30 and 40 t/ha of cow dung significantly enhanced all the yield components of okra. Based on the results, application of 15 t/ha of poultry droppings and 30 and 40 t/ha of cow dung is recommended for sustainable production of okra in the study area.
Keywords: *Cow dung, growth, poultry dropping, yield*

INTRODUCTION
Okra (*Abelmoschus esculentus*) is one of the most important vegetables grown in Nigeria. It is an annual crop grown mainly as fruits and leafy vegetables in both green and dried states in the tropics (Gibbon and pain, 1984). The crop is used as soup thickener which may also be served with rice and other food types. The fresh fruit is a good source of vitamins, minerals and plant proteins (Eke *et al*., 2008). Rehn and Espig, (1991) stated that Okra contains 20% edible oil and protein, while the mucilage is utilized for medicinal purposes. The mature stem contains crude fiber which is used in paper industries and for making ropes. Okra flowers can be very attractive and sometimes used in decorating the room (Schippers, 2000).

Vegetable growing is one of the major enterprises in horticulture which is becoming more popular due to the greater appreciation of their food values (Gardner, 2004). Okra is essentially a tropical crop and among the most commonly grown vegetables throughout Nigeria. The stem is useful as fiber, while the leaves are considered good for cattle feeds and are consumed sometimes. The seed sometimes can be roasted and used as a substitute for coffee (Farinde and Owolarefe, 2007). The essential and non-essential amino acids which Okra contained is comparable to that of soybean (Farinde, 2007).

The production of Okra is seriously affected by the use of local varieties (low yielding), sub-optimal and inappropriate manure doses. Inorganic fertilizer has not been helpful under intensive agriculture because it is often associated with reduced crop yield, soil acidity as well as nutrients imbalance (Kang and Juo, 1980; Obi and Ebo,1995; Ojeniyi, 2000). Published work on the Organic manures use in Nigeria is rather scanty. The need to use renewable forms of energy and reduce cost of fertilizing crops has revived the use of Organic fertilizer worldwide. Improvement of environmental conditions and public health are important reasons for advocating increased use of organic materials (Seifritz, 1992; Maritus and Vlelc, 2001).

Organic manures when efficiently and effectively applied or used, ensures sustainable crop productivity by immobilizing nutrient that are susceptible to leaching. (Abou El-magd, *et al.,* 2006). Nutrients contained in Organic manures are released more slowly and are stored for a long period of time in the soil, thereby ensuring long residual effects (Makinde and Ayoola,2008) supporting better root development, leading to higher crop yield (Abou El-magd *et al.,* 2005). Apart from economic cost, the use of chemical fertilizers under continuous cultivation in the tropics is not adequate to sustain crop yield. Their continuous application has been found to deplete soil organic matter (Madeley, 1990) and consequently leading to reduction in crop yield and serious degradation as well as decline in soil productivity (Adediran *et al.,* 2004).

The increased demand for Okra by greater number of people today makes it necessary to find a way of increasing its yield through the application of nutrients and adopting best agronomic practices as well as continuous cultivation throughout the year. The use of poultry droppings and cow dung do not only increase the yield of crop, but also improve the soil physical and chemical properties. Therefore, this work seeks to evaluate the effects of poultry droppings and cow dung manure on growth and yield of okra and to determine the best rate of application under irrigation.

MATERIALS AND METHODS

Pot experiment was carried out in the Screen House of the Faculty of Agriculture Experimental Farm, Nasarawa State University, Keffi Shabu-Lafia Campus (from June to October, 2015). Lafia is at altitude 181.53m above sea level. Latitude 08° 33'N and Longitude 08° 32' E. Soil sample was collected from the College of Agriculture Lafia Experimental Farm along Akurba road. The sample of top soil (20 cm) depth was collected, air dried and sieved with 2mm sieve and analyzed for physical and chemical properties before and after the experiment. Forty two pots were arranged in a Completely Randomized Design (CRD) filled with 5 kg of soil each after the pots were perforated in order to provide proper drainage. The planting material used was NH47-4 (NIHORT). The experiment consist of 4 × 4 factorial combination of four levels of cow dung (0, 20, 30 and 40 t/ha equivalent to 0g/5kg, 66.6g/5kg, 100g/5kg and 133.4/5kg of soil) and four levels poultry droppings (0, 10, 15 and 20 t/ha also equivalent to 0g/5kg, 33.3g/5kg, 50g/5kg, and 66.7g/5kg of soil) and replicated three times. The three levels of Cow Dung and Poultry Droppings were properly mixed with the soil and incorporated into pots according to the treatments combination and properly mixed with the soil. Water was then applied for 1-7 days for proper decomposition of the manures (Cow Dung and Poultry Droppings).

Two seeds of improved variety (NH47-4) were sown per pot at a depth of about 1.5cm and watered. The seeds were then thinned to one stand per pot after full emergence. Water was provided at regular interval especially at the early stage of growth and flowering stage so as to meet the crop water requirement for proper growth and development of the crop. Weeds in the pots were removed by hand pulling at regular intervals of 1-2 weeks until the day of final harvest; this is done to reduce competition for the available nutrients. Insect pest and black ants were noticed at two weeks after emergence and controlled by hand picking and application of insecticide (Karate). Matured green pods/capsules were harvested from each pot at regular intervals of 4-5 days to obtain total number of pods per plants while pod length and pod weight were measured using measuring tape and weighing scale. The pre-harvest parameters such as plant height (cm) and number of leaves were measured at 4, 6, 8 and 10 WAS. While at harvest, post-harvest parameters such as number of pods per plant, pods length (cm), fresh pod weight (g), dry pod weight (g) and green capsule yield were also measured. The data obtained were statistically analyzed using Genstat statistical software (10th Edition). Means were compared using the Duncan Multiple Range Test at 5 % level of significance.

RESULTS AND DISCUSSION

Table 1 shows the results of the effects of poultry droppings and cow dung on height of okra. The results obtained showed that application of poultry droppings at 15 t/ha produced consistently the tallest plants as compared to any other rates of poultry droppings at 4, 6, 8 and 10 WAS. However, at 8 WAS, 20 and 15 t/ha poultry droppings produced similar height of okra but they were significantly higher than those produced under 10 and 0 t/ha treatments. Similarly, at 4 WAS, 30 t/ha of cow dung produced significantly taller plants followed by 40 t/ha while 0 t/ha produced the shortest plants.

At 6 and 8 WAS, 40 t/ha of cow dung recorded the tallest plants compared to other rates of cow dung applied. At 10 WAS, every increase in the rate of cow dung significantly increased height of okra.

The significant increase in plant height with the application of 15t/ha of poultry droppings as well as 30 and 40 t/ha of cow dung this could be attributed to the fact that manure contains nutrients that are necessary for plant growth and development (Brady, 1974).

Table 1: Effect of Different Levels of Poultry Droppings and Cow Dung on Height of Okra (cm) during 2015 Dry Season

Treatment	4WAS	6WAS	8WAS	10WAS
Poultry Droppings (t/ha)				
0	16.50^{b}	20.00^{c}	22.20^{c}	25.00^{c}
10	16.60^{b}	21.27^{b}	22.43^{b}	26.73^{b}
15	17.20^{a}	22.87^{a}	24.20^{a}	28.03^{a}
20	16.63^{b}	21.47^{b}	24.27^{a}	26.93^{b}
Mean	16.75	21.15	23.03	26.17
SEM ± (0.05)	0.79	0.52	0.11	0.64
Cow Dung (t/ha)				
0	12.20^{d}	16.00^{c}	20.90^{b}	21.80^{d}
20	14.37^{c}	18.10^{b}	21.04^{b}	22.67^{c}
30	16.40^{a}	18.67^{b}	21.17^{b}	24.67^{b}
40	15.80^{b}	20.00^{a}	24.17^{a}	26.20^{a}
Mean	15.94	22.19	25.17	28.39
SEM ± (0.05)	0.11	1.01	2.21	1.55

Means having different letters along the column are statistically different at 5 % Level of significance (P<0.05).

Table 2 shows the results of the effects of poultry droppings and cow dung on number of leaves of okra. The results obtained showed that at 4 WAS, 20 t/ha of poultry droppings produced significantly higher number of leaves per plant against any other rates of poultry droppings applied. At 6 and 8 WAS, 15 and 20 t/ha produced similar number of leaves but significantly higher than 10 and 0 t/ha respectively. Meanwhile at 10 WAS, 15 t/ha of poultry droppings recorded more number of leaves, followed by 20 t/ha while 0 t/ha gave the least number of leaves of okra. The results further revealed that application of cow dung significantly enhanced number of leaves. From 4 WAS, every increase in the rate of cow dung applied significantly increased number of leaves. Application of 15 and 20 t/ha of cow dung produced similar numbers of leaves and these were significantly higher than those produced with 10 and 0 t/ha at 6, 8 and 10 WAS.

The results further indicated that number of leaves was significantly influenced by the application of 15 t/ha of poultry dropping as well as 30 and 40 t/ha of cow dung. This result obtained could be attributed to the fact that manure contains nutrients that are necessary for plant growth and development (Brady, 1974).

Table 3 shows the results of the effect of different levels of poultry droppings and cow dung on number of capsules, capsules length, fresh capsule weight, dry capsules weight and green capsules yield of okra. The results obtained showed that poultry droppings at 15 t/ha produced significantly higher number of capsules, capsules length and green capsules yield than any other rates of applied poultry droppings. Meanwhile, application of 20 t/ha of poultry droppings gave the greatest fresh and dry capsule weight against other rates of applied poultry droppings.

Table 2: Effect of Different Levels of Poultry Droppings and Cow Dung on Number of Leaves of Okra during 2015 Dry Season

Treatment	4WAS	6WAS	8WAS	10WAS
Poultry Droppings (t/ha)				
0	6.00^{b}	6.13^{c}	7.00^{c}	7.67^{d}
10	6.67^{b}	7.00^{b}	8.00^{b}	9.00^{c}
15	7.67^{ab}	8.33^{a}	9.00^{a}	10.67^{a}
20	8.33^{a}	8.00^{a}	8.67^{a}	9.67^{b}
Mean	7.17	7.33	7.17	7.42
SEM ± (0.05)	0.79	0.81	0.78	0.58
Cow Dung (t/ha)				
0	4.33^{d}	5.00^{c}	6.33^{c}	7.00^{c}
20	5.33^{c}	6.33^{b}	7.67^{b}	8.00^{b}

30	7.00^{b}	7.60^{a}	8.33^{a}	9.50^{a}
40	7.67^{a}	8.00^{a}	8.67^{a}	9.33^{a}
Mean	6.84	7.58	7.33	9.25
SEM ± (0.05)	0.11	0.78	0.86	0.79

Means having different letters along the column are statistically different at 5% Level of significance (P<0.05).

Similarly, 30 t/ha of cow dung produced significantly more number of capsules per plant when compared to other levels of applied cow dung. The results further revealed that application of 30 and 40 t/ha of cow dung produced similar capsules length, fresh capsule weight, dry capsules weight and green capsules yield but these were significantly higher than that produced with 20 and 0 t/ha of cow dung. These results could be attributed to the fact that moderate amounts of manures promote reproductive growth while excess of it promote vegetative growth and reduce yield (Haruna *et al.*, 2011).

Table 3: : Effect of Different Levels of Poultry Droppings and Cow Dung on Number of Capsules, Capsules Length, Fresh Capsule Weight, Dry Capsules Weight and Green Capsules Yield of Okra during 2015 Dry Season

Treatment	Number of Capsules per Plant	Capsules Length (cm)	Fresh Capsule Weight (g)	Dry Capsule Weight (g)	Green Capsules Yield (kg/ha)
Poultry Droppings (t/ha)					
0	3.00^{c}	6.40^{b}	16.70^{c}	11.20^{c}	1.20^{b}
10	5.00^{b}	7.60^{b}	18.95^{b}	12.67^{b}	1.40^{b}
15	7.00^{a}	9.00^{a}	19.93^{b}	12.68^{b}	1.64^{a}
20	5.50^{b}	6.90^{b}	21.24^{a}	12.95^{a}	1.30^{b}
Mean	5.50	7.60	18.96	12.23	1.40
SEM ± (0.05)	0.79	1.03	1.00	0.13	0.19
Cow Dung (t/ha)					
0	4.0^{c}	5.20^{c}	15.50^{b}	7.00^{c}	1.23^{c}
20	5.50^{b}	6.70^{b}	16.87^{b}	8.79^{b}	1.73^{b}
30	6.50^{a}	8.00^{a}	18.70^{a}	10.20^{a}	1.87^{a}
40	5.70^{b}	8.10^{a}	19.00^{a}	10.77^{a}	1.88^{a}
Mean	5.90	7.30	16.78	10.69	1.70
SEM ± (0.05)	0.11	1.22	1.17	0.19	0.09

Means having different letters along the column are statistically different at 5% Level of significance (P<0.05).

CONCLUSION AND RECOMMENDATION

From the results of this study, it can be concluded that the application of 15 t/ha of poultry droppings, and 30 and 40 t/ha of cow dung produced significantly the highest values in all the variables measured than any other rates of applied poultry droppings and cow dung.

The application of 15 t/ha of poultry droppings, and 30 and 40 t/ha of cow dung may have a positive effect on the growth and yield components of okra and it seems to be the ideal rates and is therefore recommended. However, more research should be carried out so as to ascertain the best application rates of poultry droppings and cow dung for sustainable production.

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GROWTH PERFORMANCE OF OKRA (*ABELMOSCHUS ESCULENTUS* L. MOENCH) AS INFLUENCED BY POULTRY MANURE AND NPK 15:15:15 FERTILIZER IN IGBOORA, OYO STATE, NIGERIA

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ABSTRACT

A field trial was conducted to evaluate the growth of okra plant as influenced by poultry manure and NPK 15:15:15 fertilizer. The NPK 15:15:15 was applied at 50, 100 and 150 kg/ha two weeks after planting, while poultry manure was applied at 2, 4 and 6 tons/ha applied two weeks before planting. The okra seeds were obtained from a local farmer, planted at 3 seeds per hole and thinned to one stand after a week. The treatments were arranged in randomized complete block design (RCBD). The control plants were not treated with any fertilizer. Growth parameters data were collected which included plant height, number of leaves and stem diameter. The data collected were analyzed using Analysis of Variance (ANOVA) and significant means were separated using Duncan Multiple Range Test (DMRT) at 5% level of significance. Analyzed results showed significant differences in all the growth parameters. The results from the evaluation of growth parameters showed that plants treated with 150kg/ha NPK 15:15:15 and 6 tons/ha produced highest significant growth responses.

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) belongs to a family of Malvaceae. Okra is grown in many parts of the world, especially in tropical and sub-tropical countries (Arapitsas, 2007; Saifullah and Rabbani, 2009). This crop can be grown on a large commercial farm or as a garden crop (Rubatzky and Yamaguchi, 1997). Okra is a long vegetable which is grown in tropical climate. It is one of the most popularly cultivated and consumable vegetables in Nigeria and some tropical countries in the world. Okra leaf is widely consumed in the study area as Ilasa soup. It is highly cultivated fruit vegetable in almost every market in Nigeria and Africa. The crop is usually grown on small farm holdings in mixture with staple food crops such as maize, yam, cassava, cowpea and pepper with various vegetable crops. Okra is also related to cotton and hibiscus. Okra, also referred to as lady's finger, is heat loving vegetable in the hibiscus family. Okra is important because of its nutritive values present in the leaves and fruits (Schipper, 2000). Despite the nutritive value of okra, its production is very low in most developing countries.

Okra grows in all types of soils, thriving best in a moist friable well manured soil (Kochhar, 1986). The production and economic importance of okra as vegetable in Nigeria has rapidly increased in recent years. It is therefore necessary to supplement the amount of nutrient present in the soil to meet soil requirements (NAERLS, 1993). If the yield of okra is to be increased, the low fertility soil would require addition of nutrients. One of the major causes of low yielding in okra in Nigeria is inadequate information of application rate of inorganic fertilizer and organic fertilizers especially compound fertilizer like NPK (Awe *et al.,* 2006). Several experiments on crops have generally indicated yield increase due to fertilizer application (Cooke, 1982; Adenala, 1985). Most okra farmers produce the crop at low standard husbandry and rarely care about the application level of fertilizer to the crop which resulted to low yield and much labour. One way by which the growth of okra can be increased is by applying organic fertilizers and/or inorganic fertilizers. Therefore, this trial investigated the growth responses of okra plants as influenced by poultry manure and NPK 15:15:15 fertilizers.

MATERIALS AND METHODS

The experiment was conducted at the Teaching and Research farm, Oyo State College of Agriculture and Technology, Igboora. The land was manually cleared, soil samples were collected from 0 – 20 cm depth and taken to Agronomy department, University of Ibadan for physico-chemical analysis. The soil pH in H_2O (1:1) was determined with a pH meter, while available phosphorus was estimated using Bray and Kurtz (1945) method. The soil particle size was determined using the hydrometer method (Bouyoucos, 1962), while the Macro-Kjeldahl method was used to estimate total nitrogen (Jackson, 1958). The exchangeable calcium, magnesium, potassium, sodium and effective cation exchange capacity were determined using atomic absorption spectrophotometer (Tel and Hargerty, 1984). The seed of okra (Ila Iwo variety) was obtained from okra farmer in Ibarapa Central Local Government Area of Oyo State. Sowing of seeds was done at the rate of 3 seeds per hole at plant space of 1m by 1m. Seedlings were then thinned to one at one week after sowing (WAS). Regular watering was maintained. Also manual uprooting of weeds was done on regular basis. Treatments were allotted as follows: T0 (Zero application), T1 (2 t/ha poultry manure), T2 (4 t/ha poultry manure), T3 (6 t/ha poultry manure), T4 (50 kg/ha N.P.K), T5 (100 kg/ha N.P.K), T6 (150 kg/ha N.P.K). The poultry manure was applied two weeks before planting, while NPK 15:15:15 was applied two weeks after planting. The treatments were arranged in randomized complete block design (RCBD) and replicated four times. Data collection commenced at three weeks after sowing (3 WAS). The growth parameters taken were plant height, number of leaves, number of branches and stem diameter. Number of leaves was determined by visual observation and direct counting of all the fully opened leaves per plant. Plant height was determined by using meter rule while stem diameter was determined by using venier caliper. All data collected were analyzed using Analysis of Variance (ANOVA), while significant means were separated using Duncans Multiple Range Test (DMRT) at 5% probability level.

RESULTS AND DISCUSSION

Physical and chemical properties of experimental soil

The experimental soil was moderately acidic with a pH value of 6.47, low in essential plant nutrients like nitrogen (1.70 g/kg), phosphorus (9.97mg/kg) and potassium (9.97mg/kg), below the critical values of soils in the derived savanna ecological zones. The textural class was sandy loam, with 89.4 g/kg sand, 58 g/kg silt, and 48 g/kg clay (Table 1).

Table 1: Physical and chemical properties of experimental soil

Elements	Values
pH (H_20)	6.47
Ca (Cmol/kg)	3.65
Mg (Cmol/kg)	0.76
K (Cmol/kg)	0.36
Na (Cmol/kg)	0.54
ECEC (Cmol/kg)	5.34
Total N (g/kg)	1.70
Total Org. C (g/kg)	8.70
Available P (mg/kg)	9.97
Particle size analysis	
Sand (g/kg)	89.4
Silt (g/kg)	58
Clay (g/kg)	48

Effect of poultry manure and NPK 15:15:15 fertilizer on some growth parameters of okra

Application of NPK150 produced significantly higher number of leaves compared to other treatments except PM6 at 4 and 5 weeks after planting, and NPK100 at 6 weeks after planting. At 6 weeks after planting, PM4 (10.00), PM6 (11.50) and NPK50 (11.25) were not significantly different in number of leaves of okra plant. Also, the control (8.50) was not significantly different in number of leaves when compared to PM2 (9.25), While NPK100 and NPK 150 produced 13.25 and 13.00 number of leaves which are not significantly different, but significantly ($P \leq 0.05$) higher compared to other treatments.

There was significant difference in stem diameter of okra amongst the treatments except at 3 weeks after planting. At 4 weeks after planting, application of different rates of NPK was not significantly different in stem diameter, PM4 and PM6; and, PM2 and control are not significantly different in stem diameter. At 5 weeks after planting, NPK150 produced 0.79 stem diameter significantly ($P \leq 0.05$) higher than other treatments, while PM2 (0.61), PM4 (0.57), PM6 (0.59), NPK50 (0.61) and NPK100 (0.69mm) were not significantly different in stem diameter. At 6 weeks after planting, PM6 (0.79mm), NPK50 (0.75mm), NPK100 (0.77mm) and NPK150 (0.80mm) were not significantly different in stem diameter, but were significantly higher than control (0.63mm), PM2 (0.69mm) and PM4 (0.66mm). Significant ($P \leq 0.05$) difference in plant height of okra plant was observed at 4, 5 and 6 weeks after planting. At 6 weeks after planting, NPK150 (61.25cm) and PM6 (60.60cm) were not significantly different in plant height, but were significantly different from other treatments. PM2 (50.25cm), NPK 50 (52.00cm) and NPK 100 (53.50cm) were not significantly different, but significantly higher than control (45.25cm) and PM4 (49.50cm) at 6 weeks after planting.

Table 2: Effect of poultry manure and NPK 15:15:15 fertilizer on growth parameters of *Abelmoschus esculentus* at Oyo State College of Agriculture and Technology, Igboora

TREATMENT	3 WAP	4 WAP	5 WAP	6 WAP
		Number of leaves		
Control	7.80b	8.00b	8.00c	8.50c
PM2	7.75b	8.00b	8.25c	9.25c
PM4	7.50b	7.65b	7.75c	10.00ab
PM6	8.00b	8.75a	11.25a	11.50ab
NPK50	8.25b	8.50b	9.95ab	11.25ab
NPK100	7.75b	8.00b	10.25ab	13.25a
NPK150	9.00a	9.75a	11.75a	13.00a
		Stem diameter (mm)		
Control	0.41a	0.47c	0.52c	0.63b
PM2	0.43a	0.47c	0.61b	0.69b
PM4	0.44a	0.49ab	0.57b	0.66b
PM6	0.46a	0.54ab	0.59b	0.79a
NPK50	0.57a	0.67a	0.61b	0.75a
NPK100	0.48a	0.64a	0.69b	0.77a
NPK150	0.52a	0.71a	0.79a	0.80a
		Plant height (cm)		
Control	15.75a	23.00ab	38.50b	45.25c
PM2	15.50a	28.00b	41.00a	50.25b
PM4	16.208a	31.00a	37.50b	49.50c
PM6	15.50a	34.75a	41.75a	60.60a
NPK50	16.75a	31.75a	36.25b	52.00b
NPK100	16.25a	31.00a	41.00a	53.50b
NPK150	17.00a	32.75a	44.25a	61.25a

Means follow by the same letter are not significantly different using Duncan Multiple Range Test (DMRT) at 5% probability level. WAP- Weeks after planting.

DISCUSSION

The results presented show that the growth of okra plant was significantly enhanced when treated with 150kg/ha N.P.K. 15:15:15 fertilizer and poultry manure at 6 tons/ha. These results corroborate the findings of Babatola (2006) and Sweeney *et al*. (1996) who reported enhanced crop performance as resulted from N.P.K 15:15:15 fertilizer application. This inorganic fertilizer produced equal effects on growth performance of okra treated with 6 ton/ha poultry manure.

CONCLUSIONS AND RECOMMENDATION

In conclusion, from the result obtained from the evaluation of growth of okra under different rates of poultry manure and NPK 15:5:15 fertilizer application, it was discovered that plants treated with 150kg/ha NPK 15:15:15 and 6 tons/ha poultry manure produced highest response in all the growth parameters considered in this experiment. However, the use of 6 tons/ha poultry manure is hereby recommended to okra farmers in the study area because of its role in soil nutrient management.

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THE ROLE OF *CAJANUS CANJAN* AS AN ORPHAN CROP IN ENSURING FOOD AND NUTRITION SECURITY IN NORTH CENTRAL NIGERIA AND ITS ECONOMIC AND CLIMATE CHANGE IMPACT: AN OVERVIEW

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ABSTRACT
Cajanus cajan (Pigeon pea) is a leguminous crop native to India which is widely regards to as an orphan crop and moderately used for subsistence farming in many parts of the world. This paper explores the role of Cajanus cajan in North Central Nigeria as an orphan crop in ensuring food and nutrient security and it economic and climate change impacts. The prevalence of food insecurity in North Central Nigeria is a major concern, further exacerbated by the prevalence of poverty and abject deprivation of access to food security amongst rural farming households. As such, Cajanus cajan has been identified as an orphan crop with the capacity to improve the livelihoods of smallholder farmers, providing both nutrition and economic opportunities. In terms of production, Cajanus cajan has been found to have a high nutritional value but with great sense of neglect in terms of production and research compared to other staple crops. The crop also is highly tolerant of environmental stress and can be grown in harsh climatic conditions. Thus, Cajanus cajan can play a role in mitigating the effects of climate change on North Central Nigeria, as it has been found to be productive even in areas with erratic rainfall and drought. In terms of nutrition, Cajanus cajan is a source of much needed protein for the population, with a protein content of 15-25%. This is especially important in the context of North Central Nigeria, where protein-energy malnutrition is rampant. Further, the crop is a source of other essential nutrients such as vitamins and minerals which play an important role in ensuring food and nutrient security in the region. In conclusion, Cajanus cajan has the potential to play a key role in improving food and nutrient security, as well as economic and climatic resilience, in North Central Nigeria. The crop can provide an important source of income for smallholder farmers, as well as much needed nutrition for the population. It is essential, therefore, that the crop be promoted and incentivised amongst the farmers of the region in order to reap the full potential of its economic and climate change impacts.
Keywords: *Cajanus cajan, Climate change, Economic, Orphan Crop, Nutrition.*

INTRODUCTION
Cajanus cajan, commonly known as pigeon pea, is an important orphan crop that plays a significant role in ensuring food and nutrition security in the North Central Nigeria. Orphan crop, as *Cajanus cajan* refers to traditional crops that have been neglected by modern agricultural practices and research, despite their potential to contribute to food security and resilience to climate change (Fatokimi, and Adeyemi 2021; Tadele, 2019; Pal *et al.*, 2011). To begin with, it is essential to understand the concept of orphan crops and why *Cajanus cajan* is considered as one. Orphan crops are traditional crops that have been cultivated for centuries by local communities but have received limited attention and investment in research and development compared to major crops. Despite their importance in local food systems, orphan crops like *Cajanus cajan* have been overlooked due to various reasons, such as lack of market demand, limited

commercial value, and insufficient knowledge about their potential contributions to food security (Wambrano *et al*., 2022). *Cajanus cajan* plays a crucial role in ensuring food and nutrition security in the North Central Nigeria. Some parts of the region heavily relies on this crop as a staple food, providing essential nutrients and calories to the local population and animals. Additionally, *Cajanus cajan* is known for its ability to fix atmospheric nitrogen, enriching the soil and improving overall agricultural productivity (Kinhoégbè *et al.,* 2020). Its versatility as a food crop, livestock feed, and fodder further enhances its significance in the local food system. However, the production and availability of *Cajanus cajan* are being affected by climate change. Changes in temperature, rainfall patterns, and extreme weather events pose significant challenges to its cultivation. Climate change impacts, such as water scarcity, increased pest and disease pressure, and reduced crop yield, threaten the overall sustainability and resilience of *Cajanus cajan*. (Neik *et al.,* 2023; Abaje and Oladipo 2019; Malhi *et al.,* 2021).

This article focuses on the role of *Cajanus cajan,* also known as pigeon pea, as an orphan crop in ensuring food and nutrition security in the North Central Nigeria, and its impact on climate change. The study highlights the importance of orphan crops like *Cajanus cajan* in providing food and nutrition security for smallholders, who heavily depend on these crops for household consumption. The extensive domestication and indigenization of *Cajanus cajan* through years of cultivation and natural and farmer selection classify it as an orphan crop, contributing to the conservation of agricultural biodiversity and agro-ecosystems. This article also emphasizes the need for investment in research and development efforts to enhance the productivity and resilience of *Cajanus cajan* in the face of climate change. It acknowledges the serious threats that climate change, including drought and unpredictable rainfall patterns, poses to food production and sustainable agriculture. Despite these challenges, the study highlights the resilience and sustainability of *Cajanus cajan* as a crop option for small-scale farmers in marginal lands.

The crop's ability to fix nitrogen, ease of harvest, and higher biomass production compared to other crops make it particularly preferred by smallholders. However, the article also emphasizes the significant implications of climate change on the production and availability of *Cajanus cajan*. Despite these challenges, the cultivation of *Cajanus cajan* the crop diversification can lead to positive livelihood outcomes and enhance food and nutritional security. Overall, this article provides valuable insights into the importance of orphan crops like *Cajanus cajan* in ensuring food security and highlights the need for further research to enhance their productivity and resilience in the face of climate change.

What is an orphan crop and why is *Cajanus cajan* considered as one?

Cajanus cajan, commonly known as pigeon pea, is considered an orphan crop due to its extensive domestication and indigenization through years of cultivation and natural and farmer selection (Fuller, *et al.* 2019). Orphan crops like *Cajanus cajan* play a vital role in food and nutrition security for smallholders, who often rely on these crops for household consumption (Tadele 2019; Mabhaudhi, and Chimonyo 2019). Pigeon pea is particularly preferred by smallholders because of its ability to fix nitrogen, ease of harvest, and higher biomass production compared to other crops (Mabhaudhi, and Chimonyo 2019). Additionally, *Cajanus cajan* is known for its tolerance to pests and diseases as well as its ability to grow in low-quality soils with minimal inputs such as pesticides and fertilizers (Fuller, *et al.* 2019). These traits make it a resilient and sustainable crop option for small-scale farmers in marginal lands. Orphan crops like *Cajanus cajan* are essential for the conservation of agricultural biodiversity and agro-ecosystems, contributing to the long-term sustainability of food and agricultural production (Fuller, *et al.* 2019). Furthermore, the adoption of orphan crops like *Cajanus cajan* can help reduce greenhouse gas emissions and the contribution of environmental contaminants by agriculture (Popoola *et al.,* 2022; Fuller, *et al.* 2019). Despite their importance, orphan crops have not received extensive research attention compared to major crops like rice, maize, and wheat, which provide a majority of the world population's dietary energy else why it is regarded as orphan crop. The unique characteristics of orphan crops, including their ability to grow in poor environments, resilience under stress, and provision of ecosystem services, make them a valuable resource that should be further explored and utilized (Popoola *et al.,* 2022; Fuller, *et al.* 2019). However, the seed systems of orphan crops are often associated with informal systems, with variable seed quality and minimal monitoring or control by government policies and regulations. Local technical knowledge, social structures, and norms play a significant role in driving the seed systems of orphan crops, highlighting the importance of community involvement and support for the cultivation and preservation of these crops (Mabhaudhi, and Chimonyo 2019; Fuller, *et al.* 2019).

Economic impacts of *Cajanus cajan* in North Central Nigeria?

Cajanus cajan, plays a significant role in ensuring food security in the North Central Central Nigeria. This legume crop serves as a crucial source of income for smallholder farmers in the region, particularly those facing economic challenges (Abebe 2022). Pigeon pea is ranked sixth globally among legume crops and contributes to both food and income security for farming households in Nigeria (Fatokimi and Adeyemi 2021). One of the key advantages of *Cajanus cajan* is its versatility as a multipurpose food legume, providing sustenance for resource-poor farmers in tropical regions (Kinhoégbè *et al.,* 2020). Additionally, pigeon pea by-products, when combined with grains, offer a well-balanced human diet and serve as a potential source of protein (Karri 2017). By cultivating and utilizing *Cajanus cajan,* farmers in the North Central Nigeria are able to enhance food security and improve their livelihoods.

What are the traditional uses of *Cajanus cajan* in the region?

Cajanus cajan, has a rich history of traditional uses in various regions. The roots of *Cajanus cajan* are known to possess medicinal properties and are often used as a remedy for fevers and as an anthelminthic, helping to expel parasitic worms from the body (Ayenan *et al.*, 2017; Abebe 2022).The leaves of *Cajanus cajan* have also been widely utilized in traditional medicine. They are used in the treatment of various diseases such as diabetes, fever, dysentery, hepatitis, and measles (Abebe 2022). Not only the leaves, but the seeds and roots of *Cajanus cajan* are also used for therapeutic purposes, demonstrating its versatility in traditional medicine across different nations (Ayenan *et al.*, 2017). Moreover, *Cajanus cajan* is known to be effective in addressing lung and chest disorders, further highlighting its medicinal value (Abebe, 2022). Different parts of the plant serve different purposes. For instance, the immature seeds of *Cajanus cajan* are recommended for kidney problems, while fresh seeds are used to address male urinary system problems (Ayenan *et al.*, 2017). Additionally, *Cajanus cajan* is employed in wound healing by stopping bleeding and promoting the recovery of wounds and sores (Abebe 2022).Furthermore, it is important to note that pigeon pea, the primary variety of *Cajanus cajan*,is primarily grown for human consumption in Benin and Kogi, reflecting its nutritional significance in the region (Ayenan *et al.*, 2017). Additionally, pigeon pea is integrated into cropping systems, particularly alley cropping, to restore soil fertility and manage pests (Ayenan *et al.*, 2017). Overall, these traditional uses of *Cajanus cajan* highlight its diverse range of therapeutic applications and its cultural significance in different regions.

Factors contributing to postharvest losses and storage issues in *Cajanus cajan*

Post-harvest losses and storage issues are significant challenges faced in the agricultural sector, particularly when it comes to crops like *Cajanus cajan*. However, despite its importance, post-harvest losses and storage problems continue to plague the production and utilization of *Cajanus cajan*. One of the main causes of post-harvest losses in *Cajanus cajan* is poor handling and storage practices. Farmers often lack access to proper storage facilities and knowledge on effective storage techniques, leading to spoilage and deterioration of the crop. Additionally, environmental factors such as temperature, humidity, and pest infestation can significantly impact the storage of *Cajanus cajan*, further contributing to post-harvest losses. Maintaining the quality of *Cajanus cajan* during storage poses another set of challenges. The crop is susceptible to insect pests, fungal and bacterial infections, and moisture-related issues, all of which can compromise its nutritional value and marketability. Ensuring the proper handling, processing, and storage conditions are crucial in preserving the quality of *Cajanus cajan* and minimizing post-harvest losses (Kumar and Kalita 2017).

What are the main causes of post-harvest losses in *Cajanus cajan*?

The main causes of post-harvest losses in *Cajanus cajan*, are insect pests (FRI 2021). These pests can damage the harvested crops and reduce their quality, leading to significant losses for farmers. However, it is important to note that insects are not the only culprits responsible for post-harvest losses in *Cajanus cajan*. Rodents and birds also contribute to these losses by feeding on the stored grains and causing physical damage to the harvested crops (FRI 2021). Therefore, effective pest management strategies need to be implemented to mitigate the impact of both insect pests and other potential causes of post-harvest losses in *Cajanus cajan*.

How do environmental factors affect the storage of *Cajanus cajan*?

Environmental factors play a crucial role in the storage of *Cajanus cajan*, also known as pigeon peas. One significant factor is temperature, as the temperature inside the storage bags follows the trend of the ambient temperature (Kumar and Kalita 2017). To address the issue of insect pests and improve storage conditions, various hermetic storage options have been developed, including Metallic silos, Purdue Improved Cowpea Storage (PICS) bags, and Super grain bags (Kumar and Kalita 2017). Grain temperature is another important factor that affects the respiration rate of *Cajanus cajan* during storage (Kumar and Kalita 2017). It has been found that for every 10-degree increase in temperature, the CO2 concentration in the bags increases by about 1.5% (Kumar and Kalita 2017). Environmental factors such as temperature, humidity, exposure to oxygen, CO2, and ethylene can significantly impact *Cajanus cajan* storage (Surbhit 2020). These factors can lead to major biological losses in *Cajanus cajan* during storage, resulting in lower income for farmers (Surbhit 2020). One of the significant losses is due to moisture loss, which decreases the weight of the product over time (Surbhit 2020). Therefore, it is crucial to consider and control these environmental factors to ensure proper storage of *Cajanus cajan* and minimize post-harvest losses. The use of hermetic storage bags has gained popularity in several countries as a practical and cost-effective technology for storing *Cajanus cajan*, as they not only provide protection against pests but also help maintain optimum storage conditions (Kumar and Kalita 2017).

What are the challenges in maintaining the quality of *Cajanus cajan* during storage?

Maintaining the quality of *Cajanus cajan* during storage poses several challenges that need to be addressed. One essential requirement for preserving the quality of pigeon pea is to ensure that the storage space is properly disinfected and free from any contaminants (FRI 2021). Adequate preservation techniques are crucial in maintaining the desirable characteristics of pigeon pea during storage (FRI 2021). The storage space should be covered, dry, and properly ventilated to prevent moisture buildup and the growth of mold or fungi, which can lead to spoilage (FRI 2021).

However, one of the major challenges in maintaining the quality of *Cajanus cajan* is the lack of appropriate technologies, such as integrated pest management practices, which can effectively control pests and insects that cause damage during storage (FRI 2021). Farmers use various storage containers, including calabash gourds, cans, and sacks, to store *Cajanus cajan* grains (FRI 2021). However, inadequate drying and storage facilities also contribute to post-harvest challenges, which can result in crop losses before and after harvesting (FRI 2021). In different regions, various traditional storage structures made from locally available materials are used for storing grains like *Cajanus cajan*. For example, in East and Southern Africa, cow dung ash in small bags, wood cribs, pits, iron drums enclosed with mud, and metal bins are commonly used for storing grains (Kumar and Kalita 2017). Similarly, in developing countries, simple granaries made from locally available materials are often used for grain storage (Kumar and Kalita 2017). The construction of many of these storage structures is not scientifically designed and relies on traditional knowledge and practices (Kumar and Kalita 2017). Different types of storage structures are used for short and long duration storage of *Cajanus cajan*, such as gunny bags, plastic/polythene bags, drums, and plastic containers (Kumar and Kalita 2017). In summary, ensuring proper disinfection, implementing effective pest management practices, and utilizing appropriate storage structures are vital in maintaining the quality of *Cajanus cajan* during storage.

How does *Cajanus cajan* contribute to food and nutrition security in the North Central Nigeria?

Cajanus cajan, plays a significant role in addressing food and nutrition security in the North Central Nigeria. The United Nations Sustainable Development Goals emphasize the importance of achieving food security, improving nutrition, and promoting sustainable agriculture, all of which *Cajanus cajan* contributes to. As an orphan crop, *Cajanus cajan* is recognized for its potential to contribute to sustainable food systems and enhance global food and nutrition security (Neik *et al.,* 2023). While no analytical data are currently available regarding the basic nutritional composition of *Cajanus cajan*, it is known that the protein content in both the leaves and seeds is approximately 20% (Yang *et al.,* 2020). The seeds, in particular, are highlighted as an excellent source of protein among legumes, containing the highest total amino acid content, total essential amino acid content, and branched-chain amino acid (BCAA) content (Sachanarula *et al.,* 2022; Yang *et al.,* 2020). BCAAs are essential for proper body functioning and cannot be produced by the body, necessitating dietary intake (Yang *et al.,* 2020). Additionally, *Cajanus cajan* seeds have higher nutritional properties compared to the leaves and roots, including protein, ash, and minerals such as calcium, magnesium, and iron (Sachanarula *et al.,* 2022). Furthermore, the roots exhibit better antioxidant activity compared to the seeds and leaves (Yang *et al.,* 2020). The key nutrient components in *Cajanus cajan* contribute to its antioxidant, hypoglycemic, and antibacterial effects, with the roots showing superior performance in these aspects compared to the seeds and leaves (Neik *et al.,* 2023; Yang *et al.,* 2020). Overall, *Cajanus cajan* is a grain legume crop that offers a rich source of proteins, minerals, unsaturated fatty acids in its seeds, and flavonoids, stilbenes, saponin, tannin, reducing sugars, resins, and terpenoids in its leaves (Pal *et al.,* 2011; Yang *et al.,* 2020). Further research is needed to explore unexplored areas related to the nutrient components of *Cajanus cajan* and their potential medicinal uses (Pal *et al.,* 2011).

How do these nutrient components contribute to human health?

The nutrient components found in *Cajanus cajan*, or pigeon pea (PP), have significant contributions to human health. PP seeds, in particular, are rich in carbohydrates, proteins, fats, and minerals, making them a valuable source of essential nutrients for the human body (Abebe 2022). With a protein level ranging from 18 to 25%, PP seeds serve as a valuable protein source for human nutrition (Gerrano, *et al*., 2022). While they may be deficient in sulfur-containing amino acids, PP seeds are significant sources of lysine, an essential amino acid important for human health (Abebe 2022). Additionally, PP seeds contain fiber, minerals, and vitamins such as Vitamin C and E, thiamine, riboflavin, and niacin in appropriate amounts, further contributing to overall human health (Gerrano, *et al*., 2022; Abebe 2022). The high digestibility of protein and carbohydrates in PP seeds makes them a crucial dietary component for individuals in underdeveloped nations to meet their nutritional needs (Abebe 2022). Furthermore, PP seeds have been found to improve the nutritional value of wheat-based diets by increasing the content of essential amino acids like lysine, threonine, leucine, and isoleucine. The presence of vitamin B and carotenes in PP seeds, which are often low in cereal crops, also makes them a beneficial supplement to standard cereal-based diets (Gerrano, *et al*., 2022). Overall, the abundant presence of carbohydrates, proteins, minerals, vital amino acids, and vitamins in PP seeds contributes to essential nutrients for human health (Gerrano, *et al*., 2022; Abebe 2022).

What are the specific health benefits associated with the consumption of *Cajanus cajan*?

In addition to its nutritional value, the crop has been associated with several specific health benefits. One notable benefit is its potential to lower cholesterol levels (Iweala *et al.,* 2019; Pal *et al.,* 2011). Research has shown that consumption of *Cajanus cajan* extract may have a hypocholesterolemic effect, which can be beneficial for individuals with high cholesterol levels (Chang *et al.,* 2019). Furthermore, *Cajanus cajan* has been found to have hepatoprotective activity, particularly in preventing alcohol-induced liver damage (Iweala *et al.,* 2019). Studies have shown that the methanol-aqueous fraction of the leaf extract of *Cajanus cajan* can decrease the activities of liver marker enzymes and increase antioxidant enzyme activities, indicating its therapeutic potential for alcohol-induced liver dysfunction

(Iweala *et al.,* 2019). Additionally, consumption of *Cajanus cajan* has been found to lower serum levels of liver marker enzymes such as ALT, SGPT, AST, and SGOT, further supporting its hepatoprotective properties (Chang *et al.,* 2019). Moreover, *Cajanus cajan* extract may promote bile acid synthesis and enhance the expression levels of hepatic Low Density Lipoprotein-receptor and cholesterol-7-alpha-hydroxylase, suggesting its potential role in regulating cholesterol metabolism (Chang *et al.,* 2019; Pal *et al.,* 2011). The extract-fraction from *Cajanus cajan* has also been found to reduce the atherogenic properties of dietary cholesterol in mice, highlighting its potential in preventing cardiovascular diseases related to high cholesterol levels (Chang *et al.,* 2019; Pal *et al.,* 2011). Overall, the consumption of *Cajanus cajan* shows promise in improving cholesterol levels and protecting against liver damage caused by alcohol consumption.

How does climate change affect the growth and development of *Cajanus cajan*?

Climate change poses significant challenges to the growth and development of *Cajanus cajan*, commonly known as pigeon pea. This crop, which plays a crucial role in ensuring food security, particularly in regions experiencing early impacts of global climate change, is susceptible to various stressors induced by climate change (Andrew and Martin, 2023; Musokwa and Mafongoya 2020). Changes in climatic patterns, such as increased temperatures, erratic precipitation, and flooding, can directly impact the growth of *Cajanus cajan* by causing heat stress, water stress, and waterlogging (Andrew and Martin 2023). Additionally, fluctuations in the incidence of pests and diseases, which are influenced by climate conditions, pose a significant constraint to pigeon pea production (Kinhoégbè *et al.,* 2020). However, *Cajanus cajan* has shown some resilience to these stressors, as it has been reported to be drought-tolerant and adaptable to varying nutritive profiles (Andrew and Martin 2023). Furthermore, intercropping systems involving pigeon pea, such as pigeon pea and maize intercropping, have been found to outperform sole cropping systems in terms of water use efficiency and grain yield, making them a potential adaptation strategy for smallholder farmers facing the risks and uncertainties of climate change (Musokwa and Mafongoya 2020). Despite these adaptive traits, the long vegetative cycle of *Cajanus cajan* can be a major constraint in its production, particularly in zones affected by climate change, where the lengthening of this cycle may further exacerbate the challenges faced by farmers (Kinhoégbè *et al.,* 2020). Therefore, it is crucial to develop and implement strategies that enhance the resilience of *Cajanus cajan* to climate change, such as breeding for improved tolerance to heat and drought stress, and promoting sustainable farming practices that integrate intercropping systems and pest management strategies (Musokwa and Mafongoya 2020).

What are the specific changes in temperature, rainfall patterns, and extreme weather events in North Central Nigeria?

The North Central region of Nigeria has experienced specific changes in temperature, rainfall patterns, and extreme weather events. Flooding has become more frequent in many parts of Nigeria, including the North Central region, leading to detrimental effects on infrastructure and agriculture. Rainfall patterns in Nigeria have become more variable, with increased durations and intensities, causing unpredictability in rainfall and drought patterns in the North Central region (Benson *et al.,* 2017). Rising temperatures have also been observed in Nigeria, including in the North Central region, which will lead to an increase in energy demand for air conditioning, refrigeration, and other household uses. Additionally, extreme weather events have increased in Nigeria, including in the North Central region, contributing to the current conflict and high level of insecurity in the region. These changes in temperature, rainfall patterns, and extreme weather events have significant impacts on various aspects of life in North Central Nigeria. For instance, the decrease in water levels in the Kainji Dam and other reservoirs negatively impacts the generation of hydroelectric power, affecting power distribution and industrial activities that rely on a constant power supply (Abaje and Oladipo 2019). Moreover, the region's reliance on underground water sources is likely to increase due to the expected increased variability in rainfall. The decreasing precipitation in the savannah north and increasing aridity in the northeast of North Central Nigeria have reduced opportunities for sustainable agriculture and could result in increased drought frequency and reduced surface water resources. Overall, these specific changes highlight the urgent need for adaptation measures and sustainable practices to mitigate the adverse effects of climate change in the North Central region of Nigeria (Ibebuchi and Abu 2023).

How do these changes in climate conditions impact the yield, quality, and overall production of *Cajanus cajan*?

The changes in climate conditions, including increased flooding, variable rainfall patterns, and rising temperatures, have significant implications for the yield, quality, and overall production of *Cajanus cajan,* also known as pigeon pea. Studies have shown that climate change and weather variability already affect farming conditions across sub-Saharan Africa, including Nigeria, where pigeon pea is cultivated (Renwick Leah *et al.,* 2020; Fadina and Barjolle 2018). Flooding, which has become more frequent in many parts of Nigeria, including the North Central region, can have detrimental effects on the growth and development of pigeon pea plants. Excessive water can lead to waterlogging of the soil, which negatively impacts root health and nutrient uptake, ultimately reducing the yield and quality of the crop. Additionally, variable rainfall patterns, characterized by increased durations and intensities, can also impact pigeon pea production. Low rainfall levels can result in moisture stress, leading to reduced corm growth, lower yields, and poorer quality of the harvested crop (Chemura *et al.*, 2022). Moreover, rising temperatures in Nigeria contribute to the overall impact of climate change on agriculture. Higher temperatures can accelerate evaporation rates, leading to increased water stress on pigeon pea plants. This can further exacerbate the negative effects of limited rainfall and result in reduced yields. Furthermore, elevated temperatures can also affect the flowering and pod formation processes of pigeon pea plants, potentially reducing the overall production of the crop. Overall, the changes in climate conditions pose significant challenges for *Cajanus cajan* production, and further research and adaptation strategies are needed to mitigate these impacts and ensure sustainable cultivation of this important crop in Nigeria and other affected regions (Chemura *et al.*, 2022; Fadina and Barjolle 2018; Emefiene, *et al.*, 2013).

What are the climate change impacts on *Cajanus cajan* production and availability?

Climate change has significant implications for the production and availability of *Cajanus cajan,*also known as pigeon pea. This crop, which is a vital source of dietary protein in the sub-Sahara Africa and Indian diet, plays a crucial role in global food and nutrition security (Mekonnen *et al.*, 2022; Babarinde *et al* 2020). However, the effects of climate change, including drought and unpredictable rainfall patterns, pose serious threats to food production and sustainable agriculture (Kumar *et al.*, 2022). As the impact of climate change on crop systems intensifies, there is an urgent need to develop stress-resilient crops to combat food insecurity (Malhi *et al.*, 2021). *Cajanus cajan,*as an orphan crop, has the potential to contribute to building resilience in marginal cropping systems as a climate change adaptation strategy (Mabhaudhi *et al.*, 2019). However, there are challenges associated with the underutilization of orphan legumes, including low productivity, insufficient genomic resources, hardiness, low germination, and anti-nutritional factors (Sagar *et al.*, 2022). Despite these challenges, crop diversification, including the cultivation of *Cajanus cajan,* can lead to positive livelihood outcomes and enhance food and nutritional security (Ayilara *et al.*, 2022). Therefore, it is crucial to invest in research and development efforts to improve the productivity and resilience of *Cajanus cajan* in the face of climate change.

In the face of climate change and its impact on food production, the promotion of resilient and nutrient-rich crops is essential for ensuring food and nutrition security. One such crop that plays a crucial role in the North Central Nigeria is *Cajanus cajan,*also known as pigeon pea or as an orphan crop (Popoola *et al.*, 2022; Odeny 2017). Incorporating under-exploited leguminous species like *Cajanus cajan* into food systems can contribute to both food and protein security, as these crops possess the ability to withstand adverse climatic conditions and provide essential nutrients (Sagar *et al.*, 2022; Popoola *et al.*, 2022). Consistent cultivation, conservation, and genetic characterization of under-exploited species like *Cajanus cajan* are imperative for ensuring sustainable food production and overcoming dietary deficiencies (Malhi *et al.*, 2021). However, despite their vast genetic resources and economic potential, orphan legumes like *Cajanus cajan* remain under-exploited (Popoola *et al.*, 2022). These climate-smart crops have significant agronomic features that can not only promote sustainable livelihoods but also contribute to achieving the United Nations sustainable development goals of zero hunger, improved nutrition, health, and sustainable agriculture (Odeny 2017). Unfortunately, research efforts on orphan legumes, including *Cajanus cajan,*have not received the same level of attention as commercial crops, leading to their decline in production and utilization (Sagar *et al.*, 2022). This overdependence on a few major staple crops further highlights the need to prioritize resilient and nutrient-rich crops like *Cajanus cajan* to ensure food and nutrition security in the face of climate change and unpredictable weather patterns in sub-Saharan Africa (Popoola *et al.*, 2022).

CONCLUSION

In conclusion, *Cajanus cajan,* as an orphan crop, plays a vital role in ensuring economic, food and nutrition security in the North Central Nigeria. However, its potential contributions to food security and resilience are hindered by limited research and the increasing challenges posed by climate change. This article has open and thrown more light on the importance of *Cajanus cajan* in the local food system, highlight the climate change impacts it faces and its contribution in mitigating climate change impact, and provide insights for promoting its sustainable cultivation and availability in the face of a changing climate. By addressing these issues, we can enhance food security and promote the resilience of the North Central Nigeria.

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EFFECTS OF SEEDBED, COVER CROPS AND DENSITY ON WEED CONTROL IN A YAM/CASSAVA/ MAIZE INTERCROP, AT ISHIAGU EBONYI STATE.

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ABSTRACT

A field experiment was carried out at the Teaching and Research Farm of Federal College of Agriculture, Ishiagu-Ebonyi state during the 2014 and 2015 planting seasons. Ishiagu is a tropical environment with an annual rainfall of 1350 mm, it has an average humidity of 88% and a mean annual temperature of 29^0 C and is situated on a gentle slope. The land was under grass fallow after five years of cropping.. The objective of the study was to determine effect of seedbed, cover crops species and densities on the control of weeds in yam/cassava/maize intercrop. The experimental design was a Randomized Complete Block Designin a split -split plot arrangement and replicated three times. The main plot was seedbed consisting of ridges and flats, while the sub plots were cover crop species of egusi melon, pumpkin and sweet potato. The sub-sub plots were cover crops densities of 10,000, 20,000, 30,000 plants/ha and 0 (control) plots. Data were collected on the following parameters: weed population, weed frequency and weed dry matter. Data were subjected to analysis of variance. (ANOVA) using Genstat® version 3.0 (2003) software package. Significant means were separated using Fisher's Least Significant Difference (F-LSD) at 5 % probability level. Weed population was not significantly ($p \leq 0.05$) affected by seedbed type or cover crop species. However, the density of the cover crops significantly ($p \leq 0.05$) reduced the population of weeds at 30,000 planting/ha density of cover crops, similar to the control. Also, weed dry matter was not significantly ($p \leq 0.05$) affected by the seedbeds. Similarly, cover crops species significantly ($p \leq 0.05$) reduced weed dry matter on sweet potato which maintained the least ($p \leq 0.05$) weed dry matter accumulation. Density significantly ($p \leq 0.05$) reduced weed dry matter at t 30,000 stands/ha.

Keywords: *Seedbed, Cover crop, Density, Intercrop, Weeds*

INTRODUCTION

Intercropping is the practice of growing two or more crops simultaneously in close proximity in a definite pattern, alternate rows or set of rows within the same plot (Reddy, 2012). Intercropping encourages intensification of crop production in both time and space. The most common goal of intercropping is to produce a greater yield on a given piece of land by making use of resources or ecological processes that would otherwise not be utilized by a single crop (Ouma and Jeruto, 2010). Yield advantage in intercropping occurs due to the component crops differences in the use of growth resources. When they are grown in combination, they are able to complement each other and to make better use of overall resources than when they are grown separately (Reddy, 2012). In dry land agriculture, intercropping is practiced mainly to minimize the risk of total crop failure due to the vagaries or uncertainty of rainfall rather than yield and economic advantage over sole cropping (Bello *et al*, 2013). When/where rainfall is heavy and soil depletion and leaching are eminent, intercropping acts as an insurance against failure of crops (Agris info.in, 2005). The advantages of intercropping include greater system resilience by the interplay of different crops, greater crop production (Ghaffarzadeh *et al*, 1997), reduced disease transfer and environmental benefits such as greater soil and water conservation (Gilley *et al*, 2002). These advantages occur because the component crops differ in their use of growth resources (Reddy, 2012). Also, intercropping of compatible plants encourages biodiversity, by providing a habitat for different insects and soil organisms that would not be present in a single crop environment (Altieri and Nicholls, 2004). Intercropping gives higher income per unit area than sole cropping. It acts as an insurance against monocrop failure in

abnormal year. Intercropping maintains soil fertility as nutrient uptake is made from both upper and lower layers (Reddy, 2012). There is also a reduction in soil runoff due to erosion. Several factors influence the adoption of intercropping of crops such as the region, maturity of crops, planting density, time of planting as well as socio-economic status of the farmer (Reddy, 2012). Smallholder farmers routinely intercrop cereal staple crops (maize, sorghum, millet etc.) with vegetables (pumpkin, squash, gourd, cucumber and water melon) and legumes (beans, cowpea and groundnuts), (Beatrice, 2014; Reddy, 2012).
The pulverization of the soil is aimed at obtaining good seedbed tilt, addition of humus and manure to increase soil fertility and also destruction of weeds and prevention of weed growth (Reddy, 2012). The recent increase in fuel prices has added to the cost of soil seedbed preparation thus resulting to more than 25 % of agricultural production (Reddy, 2012). Such concern has necessitated interest in finding systems that minimize negative impact on the soil, while maintaining sustainable crop production. Limited availability of additional land for crop production, with decline in yield of major food crops has heightened fear about agriculture's ability to feed a world population (FAO, 2009). This often means that newly planted lands is either located on fairly steep hillside or on relatively poor soil. In many developing countries, inequitable land distribution and land tenure and poverty had forced many families to farm on steeps and easily-eroded hillsides (Gashaw *et al*, 2017). Farmers are therefore confronted with intensification of land use with reduced fallow period because of increasing population and to maximize the acquired land (Reddy, 2012). This has led to low output with resultant low price income, reduced fallow periods with increased weed spread. Tropical farmers carry out weeding manually by hoeing and slashing. Manual hoe weeding is the most commonly employed method of weed control by the farmers. Frequent hoe weeding disturbs soil surfaces, stimulates weed germination, and weed persistence in many ways (Akobundu, 1987). Effective weeding using hired or family labour during peak periods of farm operation in certain areas of the country is not always feasible. This is because labour is scarce and the available one is being demanded by other economic sectors, thereby making wage payment to be high depending on location (Akobundu, 1987). The introduction of a smother crop like *Citrullus vulgaris* in an intercrop of Cassava/Maize/Melon is a measure against crop failure and it eliminates one or more numbers of hands weeding. Cowpea and 'egusi melon' are the most common herbaceous species intercropped with maize by traditional farmers in Nigeria (Wahua, 1984). Cowpea nodulates, fix nitrogen naturally in most tropical soils while melon protects soil from higher solar radiation and destructive impact of torrential rains thereby moderating soil temperature and reducing erosion (Wahua, 1984). In addition melon is being increasingly recommended for biological weeds control in crop mixtures as it does not reduced the yield of other inter crops (Akobundu, 1981). Cover cropping is adopted by farmers to ensure control of weeds in the farms and reduction in number of weeding. Research and experience from around the world have shown that intercropping and cover cropping system tend to suppress weeds better than sole cropping system. This is true especially with cover crops or smother crops such as forage legumes inter seeded with a main crop such as cereals. This experiment therefore was designed to determine the effects of seedbed practices, cover crops and density on the control of weeds in a yam/cassava/maize intercrop**.**

MATERIALS AND METHODS

This experiment was conducted at the Teaching and Research Farm of the Federal College of Agriculture, Ishiagu, Ebonyi State, Nigeria during the 2014/ 2015 planting seasons**.** The experimental design was a Randomized Complete Block Design (RCBD) and replicated three times and laid out as a split- split plot. The treatments were seedbed practice (factor a), cover crop species (factor b) and density (factor c). The total land area was 1825 m^2 (73 m x 25 m). The main plot size was 25 m x 13 m, the sub plot size was 25 m x 3 m and the sub-sub plot size was 5 m x 3 m with 1 m alley ways between plots and blocks. Two seedbed practices were adopted: (conventional seedbed ridges and harrowed seedbed flats). In conventional seedbed, the land was cleared by slashing weeds and ploughing. After two weeks the land was harrowed and ridged. On harrowed seedbed the plot was cleared by first slashing weeds, and ploughing after two weeks, followed by harrowing and marking out. Three cover crop species were used to control weeds, these iwere: *Citrullus vulgaris*, *Cucurbita moschata* and *Ipomea batatas*. The cover crops were planted at different densities, 10,000, 20,000 and 30,000 stands per hectare, while non was planted in the control (0 stands/ha)

Planting of Test Crops (Yam). Sets of 100 g of yam (*Dioscorea rotundata* L) cultivar '*agboghohu*' were measured out using Ohaus sensitive scale. The yam setts were planted on the crest of the ridges and on the flats, at a distance of 1 m x 1 m within rows and 1 m between rows (population density of 10,000 plants /ha).

Cassava. Cassava (*Manihot esculenta*, Crantz.), stem cuttings of 30 cm, variety TMS 0581 were planted mid-way down the ridge on the right side of the yam at a distance of 1 m x 1 m and also, on flat by the right side of yam stands at a density of 10,000 plants /ha.

Maize. The maize (*Zea mays* L) variety '*Oba super11'* seeds were planted. Planting was at the foot of the ridges and flats, opposite the cassava stands, 1 m within and 1 m between rows. Three seeds were planted per hole at a depth of 4 cm and thinned to one stand at two weeks after planting (2 WAP), (10,000 plants / ha).

Cover crops. Melon: *Citrullus vulgaris* (Schrad), (‘egusi’ melon) and Pumpkin**:** *Cucurbita moschata* (L.) ‘*Anyu*’ seeds were planted, 4 seeds per hole and at a depth of 4 cm. The seeds were planted mid-way on the ridges and flats at the same side with maize and in holes opposite the cassava stands at a distance of 1 m x 1 m. The seedlings were thinned to densities of 10,000, 20,000 and 30,000 plants/ha after two weeks of planting (2 WAP), while there was none planted on the control. Sweet potato: *Ipomoea batatas* (L.) Lam. Vines of variety TIS 2498, spreading type obtained from National Root Crops Research Institute Umudike were planted mid-way on ridges and flats. Sweet potato vine cuttings of 25 cm length with four nodes were planted at angle of 45^0 on the same side with maize opposite the cassava stands. This was done at a spacing of 1 m x 1 m for 10,000 plants/ha (15 stands), 0.5 m x1 m for 20,000 plants/ha (30 stands) and 33.3 cm x 1 m for 30,000 plants /ha (45 stands), while none was planted on the control. (0).
Staking. Yam vines were staked using bamboo sticks on which vines were trained after sprouting.
Weeding. Weeding was carried out on the entire plots at two weeks after planting using a small African hand-held hoe. The control plots (without cover crops) were weeded at the 5^{th} week and 9^{th} week after planting (farmers’ practice).
Fertilizer application. A blanket application of NPK (15:15:15) was applied at the rate of 200 kg/ha.
Data collection. Data were collected from the following parameters, weed population, and weed dry matter.
Weed population. The population of weeds per treatment was assessed with the use of a quadrat (Lado *et al.,* 2010). A 30 cm x 30cm (900 cm^2) quadrat was used to assess the population of the weeds. Using the quadrat, three random throws were made within plots. The weeds that were enclosed within the quadrat were counted, identified to species and means taken. Weed identification and naming were done using a Handbook of West African Weeds by Akobundu and Agyakwa, 1998)
Weed dry matter (g). The weed dry matter was determined using the weight of the dried weeds harvested at four weeks after planting 4 WAP, 8 WAP and 12 WAP. In the three throws of 30 cm x 30 cm quadrat into the experimental units, the weeds that were enclosed by the quadrats were harvested after identification and counting. The roots were washed to clean off the soil particles. The weeds were placed inside labeled envelops and dried in an oven at a temperature of 80^0 C for three days. At the end of the three days, when a constant weight was attained, they were removed and weighed using a sensitive measuring balance (Ohaus) and the average weight was taken (g/900 cm^2) (Longanathan, 1984)
Analysis of Data. The data collected were subjected to Analysis of Variance (ANOVA), using Gensat Version 3 statistical software. Significant means were separated using F-LSD at P= 0.05 as described by Wahua, (2010)

RESULTS AND DISCUSSIONS

Weed population.

Seedbeds and cover crop species were observed to have no significant ($p\leq 0.05$) effect on the weed population, however sweet potato maintained the least ($p\leq 0.05$) weed incidence compared to cover crops on both flats and ridges. Sarkar (1992) suggested that increase in the numbers of sweet potato vines per unit area leads to reduced weeds number. Cover crop density decreased the weeds population in both seedbeds. The 30,000 stands of cover crop density reduced the weed population similar to that of control which had few weeds. This report agrees with Holt, (1995) who reported that the manipulation of crop row spacing may reduce light interception by weeds leading to lesser weed incidence

Table 1: Effects of Seedbed, Cover crop and Density on Weed Population (900/cm^2) in 2014/2015 seasons

Seedbed	Cover crop	Density (population/ha)					Cover crop means
		No cover crop	10, 000	20, 000	30, 000	Mean	
Flat	Egusi melon	4.0	14.0	13.0	9.0	10.0	
	Pumpkin	5.0	14.0	12.0	9.0	10.0	
	Swt potato	6.0	14.0	10.0	8.0	9.0	
	Means	5.0	14.0	12.0	9.0	**10.0**	
Ridge	Egusi melon	5.0	16.0	11.0	10.0	11.0	12.0
	Pumpkin	5.0	14.0	11.0	10.0	10.0	10.0
	Swt potato	4.0	12.0	9.0	7.0	8.0	9.0
	Means	5.0	14.0	10.0	9.0	**10.0**	
	Cover crop density means	5.0	14.0	11.0	9.0	1**0.0**	

LSD 0.05 for 2 Seedbed means= NS LSD 0.05 for 2 a means at the same or different b =NS
NS= Not significant. a =Seedbed, b = Cover crop species, c = (Cover crop) density

Table 2: Effect of Seedbed, Cover crop and Density on Weed Dry Matter (g/cm^2) in 2014/2015

Seedbed type	Cover crop sp	Density(population/ha)					Cover crop means
		No cover crop	10, 000	20, 000	30, 000	Mean	
Flat	Egusi melon	4.0	42.0	47.0	42.0	34.0	
	Pumpkin	7.0	35.0	48.0	62.0	38.0	
	Swt potato	6.0	45.0	29.0	18.0	25.0	
	Means	6.0	41.0	41.0	41.0	**32.0**	
Ridge	Egusi melon	5.0	43.0	36.5	23.3	27.0	30.5
	Pumpkin	6.4	62.0	57.5	46.0	42.0	40.0
	Swt potato	6.2	47.0	24.0	17.5	24.0	24.5
	Means	5.7	51.0	35.0	29.0	**30.0**	
	Cover crop density means	5.9	46.0	38.0	34.5	**31.0**	

NS= Not significant. a =Seedbed, b = Cover crop species, c = (Cover crop) density

Weed dry matter.

Seedbed type had no significant ($p \leq 0.05$) effect on the weed dry matter. Weed dry matter was reduced by the cover crop species. Sweet potato plots had least weed dry matter as against other cover crops and this was followed by egusi melon and then pumpkin with least weeds dry matter. This suggests that the sweet potato leaves covered the ground more than the other cover crops. Dadashi *et al.* (2014), reported that due to the leaf geometry soybean reduced weed dry matter more than wheat in a weed and cover crop competition experiment. Shilling *et al.* (1985), also reported that rye cover crop in no-Seedbed system decreased weed biomass. The cover crop density significantly reduced the weed dry matter. Higher cover crop density reduced weed dry matter considerably. The control which had no cover crop but was weeded three times had the least weed dry matter followed by 30,000 stands, 20,00stands and 10,000stands of cover crops per hectare. This is in agreement with Hiroshi *et al.* (2011), who found that weed dry matter production varied greatly with the cover crop species.

CONCLUSION/RECOMMENDATION

Intercropping has a significant advantage over sole cropping. It is therefore, an important farming system that may be adopted by tropical farmers as a mitigating tool for crop failure. Also, it is likely to ensure continuous availability of food for the farmers. The cover crop in intercrops the reduced number of weeding in an intercropping system. The adoption of the intercropping system ensures minimum reduction of weeds in the farm. The cover crops ensured reduced effect of torrential rains on the soil avoiding erosion and runoffs. Higher cover crop density brought about weed reduction in the intercropping system. It is recommended that farmers should intercrop with cover crops to avoid crop failure and ensure reduction in weed dry matter accumulation by planting with population density that will not interfere with the performance of the test crops.

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BIO-FORTIFIED STAPLE FOODS: CHEMICAL COMPOSITION OF FLOURS AND SENSORY PROPERTIES OF CAKES PRODUCED FROM COMPOSITE FLOURS OF WHEAT AND PRO-VITAMIN A CASSAVA

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ABSTRACT

Biofortification of indigenous staple foods is essential in promoting food diversity, nutrients intake and tackling micronutrients deficiency diseases. Combinations of staples have been developed to improve the nutrient contents of indigenous diets. This study investigated the nutrients composition and sensory properties of cake produced from composite flours of wheat and pro-vitamin A cassava. The pro-vitamin A cassava tubers were processed into flour, which was used to substitute 10, 25, 50 and 75% of wheat flour in cakes.. The cakes were compared with 100% wheat flour cake (control) for the nutrients composition and sensory properties. The results showed that addition of pro-vitamin A cassava flour to wheat flour reduced the protein content from 11.92% in the control to 9.33% in the blend containing 75% pro- vitamin A cassava flour, while total ash, carbohydrate and β-carotene contents increased from 0.93 to 1.36%; 75.54 to 78.24% and 211.30 to 495.82μg /100g, respectively. The texture, taste and colour of all the cakes were acceptable to the panelists, with the control having the highest rating in texture (5.33), taste (5.20) and colour (5.13). Cakes with improved nutrients composition and acceptable sensory qualities can be produced from wheat flour and pro-vitamin A cassava flour blends. Thus, the use of composite flour is recommended for use in the production of acceptable cakes of high nutritional quality.

INTRODUCTION

Cakes are convenient food products that are usually sweet and often baked, prepared from flour, sugar, shortening, baking powder, egg, and essence as principal ingredients (Clerk and Herbert 2000; Atef *et al*., 2011). Cakes and other products from wheat flour are too expensive for an average person from a developing country to afford due to the increasing wheat price and importation cost, which has taken a toll on the resources of many nations around the world . Thus, there has been clamor for cheaper alternatives to wheat flour (Onyekuru *et al*., 2019). For this reason, the Food and Agriculture Organization of the United Nations (FAO) established composite flour program in 1964, having the broad objective of using local raw materials in the tropics for baking. Thus, over the years, researches have shown that High Quality Cassava Flour (HQCF) can be a good substitute for wheat (IITA, 2012, Giami*et al*., 2004).In Nigeria, there have been several policies on the use of cassava flour for bread making, but these policies have been continuously changed by successive governments for different reasons, making them ineffective (Onyekuru *et al*., 2019). Different levels of cassava flour can be used to replace wheat or rice, depending on the kind of product to be made. Cassava and wheat flours have similar properties and therefore, can be substituted for each other at different ratios for making different bakery products. The use of cassava flour was first introduced in Nigeria in 2002, via the presidential initiative on cassava, and in 2004, 10% inclusion was made mandatory for baking by the Federal Government of Nigeria (Onyekuru *et al*., 2019). This policy on cassava inclusion stipulated strategies for all categories of bakers to include cassava flour in their products in the country. This was for the reasons of stabilization of price, creation of new market, jobs and most importantly, reduction in expenditure on wheat importation (Gbola, 2012; Layi, 2012).

Cassava (*Manihot esculenta*) is one of the most important tropical root crops in developing countries and its starchy roots are a major source of dietary energy for more than 500 million people (FAO, 2005). It is the highest producer of carbohydrates among staple crops. Cassava tubers generally possess a cream or white flesh colour and do not contain a significant amount of carotenoids (Olatunde *et al*., 2020). However, the advent of yellow root cassava will complement current efforts (such as pill supplementation, food fortification etc.) to address Vitamin A deficiency (VAD) by delivering vitamin A through a staple food. Vitamin A remains a very important component of human nutrition, as it aids in vision, cell differentiation, synthesis of glycoprotein, reproduction and overall growth and development (Njoku *et al.*, 2014).Vitamin A deficiency can cause night blindness and other acute diseases. In many parts of the world, several intervention programmes aimed at reducing the associated menace caused by Vitamin A deficiency and other micronutrients deficiencies have been suggested. One of such interventions is the use of staples and snacks such as biscuits and other pastries as medium to reach the vulnerable groups, which in most cases are the pregnant women and infants. Cassava with improved nutritional value such as pro-vitamin A cassava is currently being used as an aid in reducing the prevalence of dietary Vitamin A deficiency due to its high content of β-carotene (Omodamiro *et al*., 2012). According to Aniedu and Omodamiro (2012), pro-vitamin A cassava has the potential of providing up to 25% of daily vitamin A requirements of children and women. This study therefore, reports on the chemical composition of flours and sensory properties of cakes produced from composite flours of wheat and Pro-vitamin A cassava.

MATERIALS AND METHODS

Materials

Pro-vitamin A cassava was harvested from a local farm in Makurdi, Benue state, Nigeria while whole wheat flour, sugar, margarine, salt, eggs and baking powder were purchased from Lafia modern market, Nasarawa state, Nigeria.

Processing of pro-vitamin A cassava into flour and formulation of composite flour blends

Edible Pro-vitamin A cassava flour was prepared from the raw roots by washing, peeling with knife, and slicing into 0.5cm chips, followed by oven drying (65°C, 8 hours) and milling. The powder was then, sieved with mesh of 75mm to obtain flour. The flour sample was kept in sealed plastics and stored in the refrigerator prior to use. The ratios of wheat flour and pro-vitamin A cassava composite flour blends used were 100:0, 75:25, 50:50, 25:75 and 0:100(cassava : wheat). Other ingredients used in cake production were added.

Production of Cake

Cakes were prepared by mixing 500 g flour, 250g sugar, 250g margarine, 10g baking powder, 4 eggs, water and 5gsalt in a bowl. The mixture was whipped for 30min and the other ingredients were added and thoroughly mixed. The cake batters were cut, shaped, put into greased baking pans, and s were baked at 170°C for 15min. The cakes were packaged in…. and then, stored at ambient temperature before used.

Determination of Chemical Composition of flour

Moisture, fat, ash, crude fiber, and protein contents of the flour blends were determined using the AOAC (2010) methods .Total carbohydrate was calculated by difference while energy was calculated using the Atwater Conversion factors of 4x% protein, 4x % carbohydrate and 9 x % fat) in Kcal.β-carotene content was determined spectrophotometrically as described by AOAC (2010) method.

Sensory Evaluation of cakes

Cakes were allowed to cool on racks for 30 minutes and were then assessed for the sensory attributes. Fifteen trained panelists were selected from staff and students of the Departments of Nutrition and Dietetics, and Home & Rural Economics, College of Agriculture, Sciences and Technology Lafia, Nasarawa state. The cakes were 3-digit coded and presented to the panelists in white plastic plates. Each sample was rated on intensities of sensory attributes of taste, colour, texture and general acceptability) using a 6-point scale with 6 as extremely liked and 1 as extremely disliked. Drinking sachet water was served in glass to the panelists, and they were told to rinse their mouths after tasting each cake sample. Most panelists were between the ages of 18–35 years and were regular consumers of cakes.

Statistical analysis

Experiments were conducted in 3 replicates. The means and standard deviations (SD) of the data were calculated. Statistical analysis was performed using SPSS (Statistical Package for Social Sciences, version 21.0). One-way ANOVA (Analysis of variance at the level of significance $p \leq 0.05$) was performed and means where significantly different were by least significant difference (LSD) test. Significance was accepted at $p<0.05$.

RESULTS AND DISCUSSION

Proximate composition and β-carotene contents of composite flours

Moisture, crude proteins, crude fats and carbohydrates were the major components of wheat-pro-vitamin A cassava composite flour (Table 1). The proximate composition of the composites flours were not significantly different ($p \leq 0.05$). The crude protein content of 100% wheat flour was the highest (11.92%), while that of 100% pro-vitamin A flour was the lowest (3.50%). Carbohydrate content was highest in 100% pro-vitamin A cassava flour while 100% wheat flour had the lowest. Addition of pro-vitamin A cassava flour to wheat flour reduced the protein and fat contents of the flour blends, while ash, carbohydrate and β-carotene contents increased. The proximate composition of the flours was similar to values reported in other studies on baked products produced from composite flours (Olatunde *et al*., 2016; Oyeyinka *et al*., 2014; Hooda and Jood, 2005; Oluwamukomi *et al*., 2011). Decrease in fat and protein contents and increases in carbohydrates, ash and contents of the flour blends could be attributed to the reduction in the amount of wheat flour in the composite flour blends. Wheat flour is a rich source of protein and fat compared to cassava flour, which has the bulk of nutrient as carbohydrate. The β-carotene contents of the composite flour blends s increased with increasing proportion of pro-vitamin A cassava flour in the blends, values ranged from 211.30 to 590.650 µg/100 g (Table 1). These values are also consistent with the results of Olatunde *et al*. (2016) who reported the β-carotene contents of biscuits made from composite flour of wheat and pro-vitamin A cassava to vary from246.80 to 352.40 µg/100 g). Also, the findings agreed with that of Sengev *et al*. (2016) who reported the β-carotene content range of 219-428 µg/100 g for biscuit prepared from sweet potato flour and mango mesocarp flour and bread with added mango mesocarp (Badifu *et al*., 2006). Pro-vitamin A cassava developed through food technology is relatively good source of β-carotene. Vitamin A is a fat-soluble vitamin that is naturally present in many foods as beta -carotene. It is important for normal vision, immune system, and reproduction. Vitamin A also helps the heart, lungs, kidneys, and other organs work properly. Deficiency of this nutrient is one of the major challenges facing developing nations. Vitamin A deficiency can lead to night blindness and other acute diseases.

Sensory properties of cake

The mean sensory scores for cakes from wheat and pro-vitamin A cassava flour blends are presented in Table 2. Sensory attributes (texture, taste, colour and overall acceptance) of the cake were slightly affected by the added pro-vitamin A cassava flour. Texture is characterized by the way the cake is felt in the mouth of the panelists. The brown colour of the cakes resulted from nonenzymatic reaction between sugars and proteins that occurred on heating (Maillard reaction) and also causes browning of some foods such as bread, cake etc. The scores for the sensory attributes indicate preference for cakes made with 100% wheat flour or pro-vitamin A cassava flour and others from composite flours. The texture, taste and colour of all the samples were acceptable to the panelists, with the sample from 100% wheat flour, which served as the control rated the highest in texture, taste and colour (5.33, 5.20 and 5.13, respectively). The scores for the texture and taste of the samples were consistent with the previous reports of Olatunde *et al* (2016) that cake made from wheat flour (100%) had the highest rating for colour, aroma, texture and overall acceptability. The higher rating for the control sample may be due to the fact that the judges are familiar with wheat cake, influenced their rating for the control sample. The added pro-vitamin A cassava flour affected the sensory attributes of the cake as evident in the rating by the panelists. The low ratings for cakes produced from composite flours and 100% Pro-vitamin A cassava may be due to the panelists not being familiar with the cakes. Generally, cakes produced from 100% wheat flour had and the highest ratings while cake from the composite flours and 100% Pro-vitamin A cassava flour had similar ratings for general acceptability. These results showed the possibility of utilizing wheat flour and Pro-vitamin A cassava flour in cake production.

Table 1: Proximate composition and β-carotene Contents of Wheat-Pro-Vitamin A Cassava Composite Flours

Sample	Moisture (%)	Crude Protein (%)	Crude Fat (%)	Total Ash (%)	Crude Fiber (%)	Carbohydrate (%)	Caloric Value (Kcal/100g)	β-carotene (µg /100g)
W_{100}	9.64^a±0.01	11.91^a±0.07	1.74^a±0.02	0.93^a±0.02	0.24^a±0.01	75.54^a±0.05	365.46±0.08	211.30^a±0.06
$PVAC_{25}W_{75}$	9.10^a±0.10	11.67^a±0.01	1.20^a±0.02	0.70^a±0.06	0.57^a±0.04	76.76^a±0.17	364.52±0.84	306.14^a±0.02
$PVAC_{50}W_{50}$	9.95^a±0.04	10.34^a±0.03	1.54^a±0.02	1.32^a±0.006	0.24^a±0.02	76.61^a±0.067	361.66±0.29	400.98^a±0.04
$PVAC_{75}W_{25}$	9.46^a±0.04	9.33^a±0.04	1.46^a±0.02	1.36^a±0.04	0.15^a±0.006	78.24^a±0.13	363.42±0.18	495.82^a±0.02
$PVAC_{100}$	8.10^a±0.05	3.50^a±0.05	1.12^a±0.02	1.34^a±0.02	0.30^a±0.05	85.64^a±0.14	366.64±0.50	590.65^a±0.02

Values are means ± standard deviations of 3 replicates. Means with same the superscripts in the same column are not significantly (p>0.05) different. PVAC= Pro-Vitamin A Cassava flour; W= wheat flour

Table 2: Mean Sensory Scores of Cakes produced from Wheat and Pro-Vitamin A cassava flour blends

Samples	Texture	Taste	Colour	General acceptability
A	5.33^a	5.20^a	5.13^a	5.20^a
B	4.43^a	4.73^a	4.93^a	4.87^a
C	4.67^a	4.93^a	4.80^a	5.07^a
D	4.67^a	4.73^a	4.73^a	4.93^a
E	4.67^a	5.00^a	4.80^a	4.67^a

Values within a column with the same superscripts are not significantly>0.05) different. A: Cake produced from 100% Wheat flour, B: Cake produced from 75% Wheat and 25% Pro-Vitamin A cassava flour, C: Cake produced from 50% Wheat and 50% Pro-Vitamin A flour, D: Cake produced from 25% Wheat and 75% Pro-Vitamin A flour, E: Cake produced from 100% Pro-Vitamin A cassava flour.

CONCLUSIONS AND RECOMMENDATION

Cakes with improved nutritional values and acceptable sensory attributes can be produced by substituting wheat flour with pro-vitamin A cassava flour at different ratios. Sensory and nutritional qualities of cake and flour blends was affected by addition of pro-vitamin A cassava flour. Cakes from these composite flour are good sources of proteins, energy and β-carotene, which can be potentially used to address the prevailing acute malnutrition and vitamin A deficiency among vulnerable groups especially in developing countries like Nigeria. The use of composite flour, however, is recommended to produce acceptable cakes of good sensory and nutritional quality.

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INFLUENCE OF VARIED LEVELS OF METHIONINE AND LYSINE IN SELF-FORMULATED FEED ON BROILER FINISHERS PERFORMANCE

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ABSTRACT

This study was carried out to evaluate the effects of different levels of dietary lysine and methionine on growth performance under the following parameters; feed conversion ratio, average daily weight gain and daily feed intake in broilers fed self-formulated ration coded T_1 (Control diet), T_2, and T_3. A total of 65day old Abor-Acre broiler chicks were used in the study. They broilers were housed in a brooder house for four weeks where they received equal treatment, then randomly distributed into three treatments T_1, T_2, and T_3, 20 birds per dietary treatment. Each treatment was further replicated 4 times with 5 broilers in each replicate, in a completely randomized design. Feed and water were provided ad–libitum, the research lasted for 50 days. The proximate composition of experimental ration CP, CF, EE and ME was same 23%, 4.33%, 7.9% and 3150Kcal/Kg, respectively, except lysine and methionine which were 1.465% and 0.38% (T_1) , 1.758 and 0.532% (T_2) and 1.44% and 0.410% (T_3). Average daily weight gain ranged from 33.53 – 39.38g/day in broilers fed T_2 diet, which was significantly ($P<0.05$) higher than broilers in T_3 but similar to T_1. Daily feed intake ranged from 59.50 – 64.00g and there were no significant differences among all the mean treatments. While feed conversion ratio ranged from 1.63 – 1.88, T_2 recorded least mean value of 1.63 which was better in performance when compared to T_3 (1.88). Therefore, use of lysine and methionine in broiler finisher diet, may yield a better result. Thus, broiler farmers may include dietary lysine and methionine up to 1.758% and 0.532%, respectively, when formulating ration for broiler finisher due to the positive effect on growth and development.

INTRODUCTION

Poultry business was first introduced to Nigeria in the late fifties with the importation of selected breeds of exotic birds. Poultry farming is the process of raising domesticated birds such as chickens, ducks, turkeys and geese for human and raw materials for industrial use (Ajala *et al.,* 2021). The country's standing poultry population is at present 180 million , a substantial increase from about 151 million in 2018. (FAO, 2018). Egg and meat production are the two major divisions of poultry production (USDA, 2018). Poultry meat account for about 33% of the world meat consumption and consumer's demand for high quality poultry meat is ever increasing, broilers bred for heavy deposition of muscle within short period of time reach slaughter weight between six and seven weeks of age hence, their performance is a function of genetic traits and environmental factor particularly housing and nutrition (Chen *et al*., 2013). . The component building blocks of proteins are amino acids. Amino acids requirements of broilers have been extensively studied, as well as factors that influence such requirements, such as sex, age, genetic strain, heat stress, dietary energy concentration and its interaction with crude protein level (Esonu, 2006). The wide variation in the composition and digestibility of amino acid present in feedstuffs is of great concern in diet formulation. The importance of feeding the correct amount of balanced dietary protein and amino acid for poultry is a priority for two reasons. First, protein and amino acid are some of the most expensive nutrients in feeds per weight unit (Dozier *et al.,* 2009). Second, there are environmental concerns as to nitrogen excretion in poultry waste. The concentration of protein and amino acid in broiler diets has a large impact on breast meat yield, feed to gain ratio, and number of days required to achieve the appropriate body weight for each type of market (Sterling *et al.,* 2006; Alagawany *et al.,*.2016; Bunchasak, 2009). Methionine is an amino acid of critical importance in commercial poultry diets, because it is typically the first-limiting amino acid and its deficiency may cause reduced growth performance, metabolic disorder and impaired immune system (Kidd *et al.,* 2004; Sterling *et al.,* 2006; Dozier *et al.,* 2006). It has been showed that the need for dietary lysine is greater for breast meat yield than for growth rate. The essential amino acids for the bird include methionine, lysine, tryptophan, threonine, phenylalanine, leucine and isoleucine (Esonu *et al*., 2006). Amino acids are organic compounds that contain amine (NH_2) and carboxyl (COOH) functional groups, along a side chain (R group) specific to each amino acid.

MATERIALS AND METHODS

The research was conducted in the Departmental Poultry Farm of Agricultural Technology Research Farm, Federal Polytechnic Nekede, Owerri, Imo state. The research lasted for 8 weeks but data collection started after 4 weeks of brooding. The feed materials were of same composition but vary in methionine and lysine. The experimental ration consisted of T_1, T_2 and T_3 where T_1 was the control (without lysine and methionine inclusion), T_2 and T_3 vary in methionine and lysine composition with T_2 (0.38 and 1.46%) and T_3 (0.41 and 1.44%) compositions. Table 1 shows the constituent of control T_1 diet and the nutrient composition of T_2 and T_3 with vary levels of methionine and lysine with their calculated proximate compositions. A total number of sixty-five day old broilers Arbor-Acre were used for the research. The birds were procured from a reputable source and before the arrival of the birds, the brooder house was prepared, washed, disinfected and sealed with transparent polythene for illumination, litter material was disinfected spread indoor to dry before it was spread on the floor of the prepared brooder house, and then old newspapers were used as carpet on the litter material. The brooder house was heated for 24 hours before the bird's arrival. The birds were brooded for 4 weeks under a strict observation where they received equal treatment such as feed, water, medication/vaccination, temperature and general management were performed and were fed *ad–libitum* and 3 mortalities were recorded. The birds were randomly distributed after 4 weeks of brooding into three treatments (T_1, T_2 and T_3) then, each treatment was replicated 4 times with 5 broilers in each replicate and weight of individual bird was taken for initial body weight. The treatments were randomly assigned to experimental diets; water and feed were provided *ad-libitum* for four weeks. The data collection was on the following parameters: average daily weight gain, daily feed intake, and feed conversion ratio. Data generated were subjected to analysis of variance and significant differences were established among means by using SPSS statistical software.. Least significant different was used to separate the means; the experimental design was completely randomized design.

Table 1: Feed composition and calculated chemical analysis of the experimental diets

Component amount (kg)	T_1	T_2	T_3
Maize	12	12	12
Soya	5	5	5
GNC	5	5	5
PKC	0.525	0.525	0.525
Rice bran	2	2	2
Fish	0.4	0.4	0.4
Limestone	0.375	0.375	0.375
Bone	0.375	0.375	0.375
Toxin binder	0.025	0.025	0.025
Methionine	0.00	0.0350	0.050
Lysine	0.00	0.060	0.025
Salt	0.075	0.075	0.075
Premix	0.0625	0.0625	0.0625
Total	25kg	25kg	25kg
Calculated analysis			
CP (%)	23	23	23
ME (kcal/kg)	3150	3150	3150
CF (%)	4.33	4.33	4.33
EE (%)	7.9	7.9	7.9
LY (%)	1.415	1.758	1.44
METH (%)	0.355	0.532	0.410

RESULTS AND DISCUSSION

The overall performance of broiler birds fed the experimental diets, are shown in table 2), the average daily weight gain (ADG) ranged from 33.53 – 39.38g/d with T_2 recording the highest mean value which was a reflection of daily feed intake. (DFI). This may be attributed to breast muscle development due to level of lysine in T_2 compared to T_3 (Kidd *et al.,* 2004 and Kerr *et al*., 1999) recorded low level of lysine % against this current report which was higher (1.465%), followed by T_1 and T_3 that recorded the least value (33.53g/d) of ADG. There were significant differences ($p< 0.05$) among T_2 and T_3 but, T_1 was similar to T_2 and T_3 in ADG . The DFI range from 59.50 - 64.00g with T_2 recording the highest mean value, followed by T_3 and T_1 (control) recorded the least mean value on daily feed intake, no significant effect of trial diets was observed in term of DFI while FCR was significantly different among T_2 and T_3 conforming to earlier report (Mehrdad, 2013) who recorded significant different on feed conversion ratio but T_1 was similar to T_2 but significantly different from T_3..

Table 2: Performance of broiler finishers fed varied levels of lysine and methionine

Parameters	T_1	T_2	T_3	SEM
IW (g)	**450**	**410**	**490**	
FW (g)	**2600**	**2750**	**2655**	
ADG (g/day)	**36.16^{ab}**	**39.38^{a}**	**33.53^{b}**	**0.99**
DFI (g)	**59.50**	**64.00**	**62.75**	**1.15**
FCR	**1.650^{b}**	**1.630^{b}**	**1.880^{a}**	**0.43**

^{ab}: means with different superscript differ significantly; ^{SEM}: means standard error of mean; ^{IW}- initial weight, ^{FW}- final weight, ^{ADG}- average daily weight gain, ^{DFI}- daily feed intake, ^{FCR}- feed conversion ratio.
Legend:

SUMMARY

Results from this study showed that birds fed treatments T_1 (control) and T_2 diets were significantly similar ($P < 0.05$) but higher than the birds fed T_3 in average daily weight gain. However, T_1 and T_3 were similar but there was significant different ($P < 0.05$) in mean values of T_2 and T_3. The daily feed intake showed that there was no significant differences among broiler finishers fed T_1, T_2 and T_3 diets whereas, feed conversion ratio was significantly different ($P < 0.05$) in T_2 and T_3 but T_1 and T_2 shows no significant different.

CONCLUSION

Therefore, use of lysine and methionine in broiler finisher diet, may yield a better result. Thus, broiler farmers may include dietary lysine and methionine up to 1.758% and 0.532%, respectively, when formulating ration for broiler finishers, due to the positive effect on growth and development.

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PRODUCTION AND QUALITY EVALUATION OF COMPLEMENTARY FOODS FROM MILLET, SOYBEAN AND EGG BLENDS

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ABSTRACT

Local indigenous cereals, legumes and dairy foods are good sources of cheap high-quality macro nutrients and micro nutrients. This study aimed at producing and evaluating the qualities of complementary foods formulated from locally available food materials. Five foods were formulated from blends of millet flour, soybean flour, and egg powder in ratio (100:0:0; 90:5:5; 80:15:5; 70:20:10; 60:25:15, millet: soybean: egg). The mineral composition antinutrients SCREENING and sensory properties of the formulated samples were determined using standard methods. The formulated was rich in iron (2.00-2.80mg/Kg), zinc (1.80 -2.30 mg/Kg), sodium (240.33-247.33 mg/Kg) and calcium (27.00-30.33 mg/Kg). F tannin was found t in all food samples, saponin was present in samples D and E while flavonoid was present in sample C. Oxalate was absent in all the food sample. The sensory evaluation results showed no significant difference (p<0.05) in all samples although sample D with 70% millet flour, 20% soybean flour and 10% egg flour ranked best in terms of color, aroma, mouth feel taste and general acceptability. This study has demonstrated that the use of millet-soybean-egg composite flour in the production of weaning food would help to improve the food.

Keywords: *Millet, Soybean, Egg, Minerals, Antinutrients*

INTRODUCTION

Complementary foods are foods given to infants in addition to breast milk when breast milk nutrients become insufficient to provide their nutritional needs(Onyekwere, 2007).Nutritious complementary foods, also known as weaning foods, are introduced and cover the period from the age of six to twenty- three months in developing countries (UNICEF, 2021). In Nigeria, as in most African countries, the introduction of complementary foods usually begins between the fourth and the sixth month of child's life and it involves the use of a semi-liquid porridge prepared from local staple cereals or tubers. During this period, infants are fed with complementary foods two to three times a day for children age between six to eight months and two to four times daily for children between nine and eleven months of age (WHO, 2023).

The lifelong impact of improper and inadequate feeding may include low school performance, reduced productiveness, low intelligent quotient and social development or chronic diseases (Nestel *et al.*, 2003). Hence, improved and adequate complementary foods at this period of life are needed for the child's normal growth and cognitive development.

Protein/energy malnutrition is mainly due to the unavailability of low-cost, high-quality food for the low-income family. However, local indigenous cereals , legumes and dairy foods are good source of cheap high-quality macro nutrients and micro nutrient (Muhimbula *et al.*, 2011). Thus, the present study aimed at producing and evaluating the nutritional qualities of complementary diets formulated from locally available food materials such as millet, soybeans, and egg

MATERIALS AND METHODS

Millet, soya beans and egg.s used in this study were purchased from a community market n Lafia Metropolis. The millet and soya bean were identified at the Department of Agronomy, Faculty of Agriculture, Nasarawa State University Keffi as *Pennisetum glacum* and *Gycine max*, respectively.

The millet grains were cleansed, washed, soaked to ferment for 24h, drained in a basket, cover ed with cotton material and put in a dark place, germinated for 72h, washed and sun dried for 72h, dry milled with attrition mill and sieved through a wire,mesh to produce millet flour.

Soybeans were sorted, cleansed, washed, soaked for 12hr to fermentation, drained , covered with a cotton material and kept at room temperature, germinated for 48hr, washed and removed seed coat, sun dried, dry milled with attrition mill and sieved through a wire mesh to produce soybean flour..

The eggs (whole) were carefully broken, whisked, oven dry (60^o C for 48h) and milled with attrition mill to produce egg powder.

he flour blends were formulated as shown in Table 1 to produce the complementary foods and were then stored in airtight containers at ambient temperature (25 - 30oC) until used.

Table 1: Blend ratios of the ingredients

SAMPLE	MILLET(%)	SOYBEAN(%)	EGG(%)
A	100	—	—
B	90	5	5
C	80	15	5
D	70	20	10
E	60	25	15

Mineral Determination

Mineral element (P, Mg, , K, Na Ca, Mn, Cu and Fe)concentrations were determined using Atomic Absorption Spectrophotometer (Hitachi,model 180-80). Phosphorus was determined Spectrophotometrically by the vanadomolybdate method (AOAC, 2012).

Antiinutrients screening

Oxalate in the flour samples was screening using the method of Peters *et al.*,(2016). Phytate, saponin and tannins in the flour samples were screened described by Awogbenja *et al.*, (2018] while those of the saponin and tannins were done using AOAC (2012) methods.

Evaluation of Sensory Properties

The sensory properties of the were evaluated on a 9-point Hedonic scale, where 9 represents liked extremely, 1 represents disliked extremely, and 5 neither liked nor disliked. Twenty (20) trained judges comprising of staff of the Department of Nutrition and Dietetics, Faculty of Agriculture, Nasarawa State University, Keffi evaluated the bread attributes crumb texture, crust colour, taste, aroma and overall acceptability. Panelists were provided with coded samples and warn water for mouth gargling after each session.

Statistical Analysis

All measurements were done in at least in two replicates, and the results were subject to one factor analysis of variance (ANOVA), using software package , SPSS 16.0.The significance of differences was evaluated by Duncan's test, at $P<0.05$. The results are represented as mean values ± standard deviation (SD). Significance was accepted at $p<0.05$

RESULTS AND DISCUSSION

The mineral composition of the formulated diet is presented in Table 2. The phosphorous concentrations ranged from 269.00mg/kg(sample B) to 285mg/kg (Sample E), Calcium contents ranged between 27.00mg/kg and 30.33mg/kg, increasing with decrease in the amount of millet.The highest concentration of iron was found in sample A, Zinc was highest in sample B (2.30mg/kg). Magnesium was the lowest mineral, being highest in sample A (0.60mg/kg). Mineral with the highest level was phosphorous , followed by sodium, then calcium and then iron. Phosphorus is the second most abundant mineral in the body after calcium. In form of various phosphates, phosphorus performs a wide variety of essential functions including liberation and utilization of energy from food. Ayo *et al*.(2018) reported lesser amount of potassium, calcium, phosphorous and sodium for bread made from a blend of acha and mushroom. The increase in potassium, calcium, phosphorous and sodium in the current study may be attributed to soybean and egg supplements. Calcium intake in diabetics has been shown to be beneficial and likely to reduce osteoporosis in older diabetics (Ayo *et al.,20*18). The increase magnesium level is vital, magnesium plays many crucial roles in the body, such as supporting muscle and nerve function and energy production. Low magnesium levels usually don't cause symptoms. However, chronically low level, can increase the risk of high blood pressure, heart disease, type 2 diabetes and osteoporosis. The moderate sodium level is also vital as the human body requires a small amount of sodium to conduct nerve impulses, contract and relax muscles, and maintain the proper balance of water and minerals.

Table2: Mineral Composition (mg/kg) of Millet -Soybean-Egg complementary foods

Sample	Fe	Zn	Mg	Ca	Na	P
A	2.80±0.00^{a}	2.00±0.10^{b}	0.60±0.02^{a}	30.33±1.53^{a}	247.33±2.52^{a}	280.00±2.00^{c}
B	2.63±0.15^{b}	2.30±0.10^{a}	0.58±0.02^{b}	28.67±2.08^{b}	244.67±2.08^{b}	269.00±1.00^{d}
C	2.00±0.10^{d}	1.97±0.21^{bc}	0.55±0.03^{d}	27.33±1.53^{bc}	242.00±1.00^{c}	287.33±3.05^{a}
D	2.33±0.15^{c}	2.27±0.15^{a}	0.56±0.01^{bc}	27.00±1.00^{c}	245.67±5.86^{b}	269.67±2.08^{d}
E	2.10±0.10^{d}	1.80±0.10^{bc}	0.54±0.01^{d}	27.00±1.00^{c}	240.33±0.58^{d}	285.00±1.00^{b}

Means (±SEM) with different superscripts in the same column are significantly different at P<0.05. A= Millet:100 %, B=Millet:90,% Soybean :5:% Egg:5%; C=Millet:80%, Soybean :15%: Egg:5%; D= Millet:70%, Soybean :20%: Egg:10%; E= Millet:60%, Soybean :25%: Egg:15%

The screening of the f antinutrients in the formulated diet is presented in Table3. Tannin was present in all the samples, saponin was present in samples D and E while flavonoid was present only in sample C. Oxalate was absent in all the food sample. The result of this study is similar to that of Karishma and Pravin (2016) who reported the presence of tannin in bread fortified with germinated horse gram.. Oxalate and tannin not only interfere with mineral absorption, but also impair protein digestibility. Therefore ,their presence indicates the need for further processing such as combination of germination and fermentation methods .
NO TABLE 2

Table 3: Screening of Anti-nutrients in Millet -Soybean-Egg Complemnetary foods

SAMPLE	TANNINs	SAPONINs	FLAVONOIDS	OXALATEs
A	+	-	-	-
B	+	-	-	-
C	+	-	+	-
D	+	+	-	-
E	+	+	-	-

A= Millet:100 %, B=Millet:90,% Soybean :5:% Egg:5%; C=Millet:80%, Soybean :15%: Egg:5%; D= Millet:70%, Soybean :20%: Egg:10%; E= Millet:60%, Soybean :25%: Egg:15% + . Present -. Absent

The sensory properties of the formulated diets are presented in Table 4. The sample D had the best appearance , scoring 7.40 in color, sample C had the best aroma with a mean score of (7.60) while sample D had the highest score(6.98) for mouth feel and sample D (7.93) had the best texture. For overall acceptability, sample D performed better than the other samples.There were significant(p<0.05) differences in colour and taste among samples. No panelist showed total dislike for the taste of any of the samples, implying that the taste of the samples was not affected by the level of supplementation. Aroma is related to taste, a good level of flavour intensity influences taste.

Table 4: Sensory properties of Millet -Soybean-Egg Complementary foods

Sample	Color	Aroma	Mouthfeel	Taste	General acceptability
A	6.56^{bc}	5.76^{a}	6.20^{b}	6.21^{b}	5.80^{a}
B	6.76^{ab}	5.52^{a}	6.28^{b}	6.25^{b}	6.04^{a}
C	7.44^{a}	6.96^{a}	7.48^{b}	6.38^{b}	6.56^{a}
D	7.80^{a}	6.56^{a}	7.80^{a}	7.50^{a}	6.60^{a}
E	6.64^{b}	6.24^{a}	6.63^{b}	5.20^{b}	5.70^{b}

Means with different superscripts in the same column are significantly different at P<0.05

CONCLUSION

The study has demonstrated the use of millet-soybean-egg composite flour in the production of complementary foods the mineral contents t) as well as the sensory qualities of the formulated products. All the raw materials used for the production of the foods are locally available and the complementary foods do not require special skill for the preparation.

It is recommended that the use of indigenous food crops should be encouraged for the production of complementary foods as they cheap and provide adequate nutrients needed for growth and development of infants

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DETERMINATION OF SELECTED MINERAL ELEMENTS AND PROXIMATE COMPOSITION OF DRIED *MORINGA OLEIFERA* LEAVES FROM IN IGBOORA, IBARAPA LOCAL GOVERNMENT AREA, OYO STATE, NIGERIA.

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ABSTRACT

This study aimed at determining the nutrients and mineral composition in the Dried Moringa oleifera. Leaves were removed from leaf branches, spread on a clean plastic tray and air dried at room temperature for 3 weeks, grounded and was taken to laboratory for the determination of selected mineral and proximate analysis which was done by standard method. The result indicated that Moringa oleifera had highest value of Magnesium (61.74 mg/L) followed by Calcium (19.14 mg/L) while Lead had the lowest percentage of (0.01 mg/L). It was revealed that Carbohydrate had the highest percentage composition of (50.20%), Crude fibre (20.50%) while Fat content had the lowest percentage composition of (2.68%). However, from this study, it was discovered that Moringa oleifera contained high amount of magnesium which is needed for more than 300 biochemical reactions in the body. It was discovered from the findings, that Moringa oleifera has all the necessary minerals in right proportions and is fit for consumption.
Keywords: *Moringa oleifera, Magnesium, Zinc, Carbohydrate, Lead, Crude fibre and proteins*.

INTRODUCTION

Moringa oleifera commonly referred to as "Drumstick tree" belongs to the plant family *Moringaceae*. It is widely cultivated in semiarid, tropical and subtropical areas. The plant may be consumed as vegetable to improve nutrition, can be taken as medicinal plant to cure ailments and improve health, cultivated as forage for livestock, and used as live fencing. Powder produced from the seed is used as an effective primary coagulant for water treatment, and also possess the potential to remove cadmium from aqueous system (Pritchard *et al*., 2010; Sánchez- Martín, 2010). The seed extract has been shown to have ameliorative effect on liver fibrosis in rats and also contain certain antitumor promoter. Crude extracts and essential oil from *Moringa oleifera* possess anti-fungal activity against certain dermatophytes (Chuang *et al.,* 2007). The leaves possess antioxidant properties (Hamza, 2010). Some phytochemicals derived from the seeds possess insecticidal properties against mosquito (Prabhu *et al*., 2011).

This plant contains a considerable amount of various nutrients, and has been suggested as a good supplement for such nutrients as protein, fibre and minerals. Also, it can be included in diets to supplement daily nutrient needs which could help to fight against many diseases as nutraceuticals. *Moringa* is rich in many vitamins, including vitamin A, several forms of vitamin B, vitamin C, vitamin D and vitamin E. In fact, it has more of these vitamins than a variety of foods (such as carrots, oranges and milk) that claim to be excellent source of these vitamins. The *Moringa* tree grows quickly in many types of soil environments. Much of the plant is edible by humans or by farm animals. *Moringa oleifera* leaves can be used in food preparation and also brewed as a tea, either alone or in combination with milk (Fuglie, 2006).

The term heavy metal refers to any metallic chemical element that has a relatively high density and may be toxic or poisonous even at low concentrations (Alloway and Ayres, 1993). Heavy metals include zinc, lead, calcium, mercury etc. Heavy metals are natural components of the earth crust. They cannot be degraded or destroyed. To a small extent they enter our bodies via food, drinking water and air. As trace elements, some heavy metals (e.g. Cu, Zn, Fe) are essential for maintaining the human body metabolism. There are several sources of metal poisoning which include water contamination via lead pipes, food contamination and inhalation of contaminated dust (APHA, 2000). Heavy metals are dangerous, because they tend to bioaccumulate. (Bio accumulation means an increase in the content of a chemical in a biological organism over time, compared to the chemicals content in the environment). Diverse amounts of heavy metals are cosmopolitan in soil, water, air, sediments and plants.

Therefore, this research is interested in studying the nutrient and proximate composition of fresh and dried *Moringa oleifera* to ascertain whether it has the nutrient contents in the right proportion that can serves medicinal purpose or other functions.

MATERIALS AND METHODS

Study Area: The experiment was carried out at the Research Laboratory of Oyo State College of Agriculture and Technology, Igboora. Igboora lies on latitude 7° 15'North and longitude 3° 30' East of the equator with annual rainfall of 150mm and temperature of 27°C Oyo State. The area falls within Southwest region of Nigeria and noted for both hot and cold weather condition (Sanusi, 2011).

Sample Collection and Preparation: The Fresh leaves of *Moringa oleifera* were plucked from the Moringa tree growing at Igbo-ora. The leaves were removed from leaf branches, spread on a clean plastic tray and air dried at room temperature for 3 weeks until no traces of water was founded in it. This was done to avoid interference during analysis and also to reduce the level of water content.

Nutrient determination of *Moringa oleifera*

Determination of Calcium: washed moringa sample was left in water to make it alkaline (pH 12.5 to 13). An indicator that can form a colored complex with EDTA is then added to the solution, and the solution is titrated with EDTA which later showed colour blue (Joseon, 2005).

Determination of Magnesium: Magnesium was determined using EDTA titrimetric method. 10ml of the digested sample was pipetted into 250ml conical flask, a pinch of KCN, a pinch of hydroxyl ammonium chloride solution and 5ml of 10% potassium hydroxide was added and shaken gently until the solid dissolved. A pinch of Eriochrome black T indicator was added and the mixture was titrated with 0.01M EDTA solution until the wine-red colour changes to blue which is the end point (Andreaw *et al.*, 2005).

Determination of Ash Content: The ash content was determined using AOAC method. 5g of the sample was weighed into a crucible in a muffle furnace and heated at 550°C for six hours until it became gray ash. The dish was removed from the muffle furnace using crucible tong and placed in a desiccator to cool. After cooled it was re-weighed and the weight of ash was obtained by the differences (Wang, 2005).

Determination of Moisture content: The moisture content of the sample was determined using the procedure prescribed by Fuglie (2005). The Petri-dish was cleaned thoroughly and placed in oven to dry. 5g of the sample was poured into a pre-weighed Petridish, and then placed in an oven to dry at 105°C for two hours. The dish and dry sample were transferred into a desiccator to cool at room temperature before being weighed again. The experiment was repeated until constant weights were obtained.

Determination of Fat content: Fat was determined using soxhlet fat extraction method. 250ml boiling flask was cleaned thoroughly and dried in oven at 105°C for 30 minutes and then placed in a desiccator to cool. 2g of the dried sample was weighed accurately into labeled thimbles. Cooled boiling flask was filled with 200ml of petroleum ether and boiled at 40-60°C. The extraction thimble was plugged lightly with a cotton wool and the boiling flask containing the petroleum ether was placed in the extraction thimble to boil and the soxhlet apparatus was allowed to reflux for six hours. The thimble was removed carefully, and the petroleum ether on top of the container was collected and drained into another container for reuse. When the flask is free of petroleum ether, it was removed and boiled for an hour at 105°C. It was finally transferred from the oven into a desiccator to cool before weighing (Amaglo *et al.,* 2010).

Determination of Crude Fibre content: Crude Fibre content was determined by Weende's method. 2g of the sample was weighed into a 250ml conical flask and 200ml of 1.25% H_2S0_4 was added and the mixture was boiled under reflux for 30minutes. The solution was filtered with a filter paper; the residue was later rinsed thoroughly with hot water until there was no more acidic content when tested with pH paper. The residue was transferred into a 250ml beaker and 200ml of 1.25% NaOH was added and boiled for 30minutes in a digestion apparatus after filtered and rinsed with distilled water until the filtrate was neutral when tested with pH paper. The residue was transferred into a crucible and placed in electric oven at 100°C for eight hours to dry. It was then removed and placed in a desiccator to cool before weighing. After weighing, the sample was incinerated, cooled in a desiccator and reweighed (Lowel *et al.,* 2006).

Determination of Protein: Protein content of the moringa sample was determined using the Kjeldahl method. The total nitrogen was estimated and multiplied by a conversion factor of 6.25 to obtain the protein content. 0.5g of the sample was weighed into a Kjeldahl digestion flask. A tablet of selenium catalyst was added to it. 20ml of H_2SO_4, 10g of $NaSO_4$, 1g of $CuSO_4$ were also added to the flask and digested by heating under a fume cupboard till the solution digested completely and changed to blue colour. The solution was carefully removed and allowed to solidify for 24hrs until a white colour obtained (Fuglie, 2005).

Determination of Heavy Metals in *Moringa oleifera*

Determination of Chromium: Chromium determination was carried out by EDTA titrimetric method using Xylenol Orange as an indicator. 15ml of the moringa sample was measured into a 250ml conical flask. Then 5ml of distilled water, 3 drops of xylenol orange indicator and 1 drop of dilute H_2SO4 was added to the sample solution. Thereafter, the colour turned to light red and hexamine powder was added until the colour changed to deep red. It was then titrated with 0.05m EDTA until colour change from deep red to initial red was observed (Fuglie, 2005)

Determination of Zinc: This was determined by EDTA titrimetric method. 2ml of moringa sample solution was measured into a conical flask and 2ml of buffer solution was added to it. Then, 2 drops of Eriochrome Black T Indicator was added and the mixture titrated with 0.01 EDTA until the colour changed from wine red to blue (Becher *et al.*, 1996)

Determination of Lead: The Lead content in the moringa sample was determined using Spectrophotometric method. 10ml of the sample solution was measured into a beaker, followed by addition of 5 drops of 10% KCN, 5ml of 1.2M NH_3 solution and 5ml of 10% $NaSO_4$. The resulting mixture was filled up to the 50ml with distilled water. The spectrophotometer was set at wavelength of 430nm after calibration and the absorbance reading of the sample solution taken (Makkar and Becker, 1996).

Determination of Iron: In determination of iron content, 5ml of the moringa sample was pipetted into a 50ml of volumetric flask. 5ml of 17% CH_3COONa was then measured into the digested sample in a volumetric flask followed by addition of 0.5ml of 10% hydroxylamine hydrochloride and 5ml of 0.25% O-phenanthroline. Then the mixture was made up to 50ml with distilled water and allowed to develop for 30mins before the absorbance reading was taken using spectrophotometer. The wavelength of spectrophotometer was set at 510nm for Iron (Amaglo *et al.*, 2010).

Determination of Copper: In determination of copper content, 10ml of the digested moringa sample was measured into 50ml of volumetric flask. 10ml of 0.01M NH_4OH was added to the solution and the resultant mixture made up to 50ml using distilled water. It was allowed to develop for 30mins, before absorbance reading was taken with the aid of the spectrophotometer at wavelength of 620nm (Abalaka *et al.*, 2009).

RESULTS

The mineral elements determinations of *Moringa oleifera* showed different values. The obtained values varied from 61.74 – 0.01(mg/L) for nutrient. The *Moringa* leaves that were used in this study contained appreciable amount of minerals, which compared well with those of other authors. Among the mineral elements detected from *Moringa oleifera*, Magnesium had the highest percentage composition of (61.74 mg/L) while Lead had the lowest percentage of (0.01 mg/L). Calcium had (19.14 mg/L) while vitamin C had (16.23 mg/L) followed by Potassium (8.17 mg/L), Iron (3.5 mg/L), Zinc (2.13 mg/L), Copper (0.17 mg/L) and Vitamin B (0.12 mg/L) respectively. Chromium was not detected in the *Moringa oleifera*.

It was revealed that Carbohydrate had the highest percentage composition of 50.20% while Fat content had the lowest percentage composition of (2.68%). Crude fibre had (20.50%), Ash content was (12.30%), Protein had (9.0%) and Moisture content revealed (5.30%) respectively.

Table 4.1: Mineral elements Composition of *Moringa Oleifera*

Mineral Elements	Composition (mg/L)
Calcium	19.14
Potassium	8.17
Magnesium	61.74
Iron	3.5
Copper	0.17
Zinc	2.13
Chromium	Not Detected
Lead	0.01
Vitamin B	0.12
Vitamin C	16.23

Table 4.2: Proximate analysis percentage of *Moringa Oleifera*

Proximate Analysis	Composition (%)
Ash	12.30
Carbohydrate	50.20
Fat	2.68
Crude fibre	20.50
Moisture	5.30

Protein	9.02

DISCUSSION

The calcium for the present was low and is similar to the observation of low calcium reported by Thippeswamy *et al.* (2020). The present result deviated from high value of calcium (199.23ppm) reported Moringa by Mahima *et al.* (2014) in India. Potassium reported for this study was low compared to (430.00 ± 8.37) reported by Okiki *et al.* (2015). Mg reported for the present study was very high and is in agreement with observation of Okiki *et al.* (2015) in Ado Ekiti. Iron and Copper values from this study were very low to high values reported by Mahima *et al.* (2014) while similar observation of low Iron values was observed by Okiki *et al.* (2015). Deviated values of iron (19.05 ppm) and copper (8.733 ppm) which was high were observed by Thippeswamy *et al.* (2020) and Olugbemi *et al.* (2014) in *Moringa oleifera*. The low value of Zinc observed for this study could be due to low level of Zn in the soil used for moringa plantation. This present result is contrary to the observation of Okiki *et al.* (2015), Thippeswamy *et al.* (2020) and Olugbemi *et al.* (2014) in which all reported higher values of Zinc in their study areas. The reason for the variations in values can be associated to varied soil where the moringa was grown. Chromium was not detected at all in this study, which indicated low level of highly impacted metals in the soil. Lead values reported for this study was very low which may be due to low level of lead in the soil that moringa was planted. Vitamin B reported for the present study was low compared to the observation of Zahidul Islam *et al.* (2021) and recommended Dietry Allowance of 19% for vegetables. Vitamin C reported in this study was high more than the limit (12%) required by RDA. Similar observation of high values of Vitamin C was also reported by Zahidul Islam *et al.* (2021).

The determinations of some proximate in *Moringa oleifera* plant parts (leaves) materials were restricted to those that are cultivated in Igboora town and the results obtained from the analysis revealed that concentration levels of the sampled leaves varied in values for proximate analysis. Carbohydrate that has the highest percentage composition implies that the *Moringa oleifera* leaves examined are very rich in carbohydrate and serves as source of energy to the consumers. Similar observation was reported by Bamishaiye *et al.* (2011) and Okiki *et al.* (2015) who also reported high carbohydrate value, though, the present study observed high value more than (47.09%) and (37.87%) reported. Ash content had the lowest percentage composition and is in contrary with value of Ash reported by Akindahunsi and Salawu (2005) for *Ocimum gratissimum* and *Hibscus esculentus* leaves (8.00%) and (9.15%), (9.25%) reported for *Moringa oleifera* leaves by Mahima *et al.* (2014) and Bamishaiye *et al.* (2011). Fat content in this study reported low value which is necessary for good health, i.e. low cholesterol that can lower the risk of high blood pressure. This observation is in line with the report of Bamishaiye *et al.* (2011) in *Moringa oleifera* Akindahunsi and Salawu (2005) in *Amaranthus hybridus* and *Corchorus africanum*. Salma (2020) also reported low value of fat for *Moringa oleifera* leaves. Low fat contents have been previously reported by Makkar and Becker (1996), Oduro *et al.* (2008) and Fuglie (2001) for *Moringa oleifera.*

High value of crude fibre that was reported indicated high digestibility when the moringa is taken, and the value is lower compared to the report of Mahima *et al.* (2014) (23.09%), Olugbemi *et al.* (2010) (27.44%), Mutayoba *et al.* (2011) also reported (30.65%), all for *Moringa oleifera* leaves. Protein that revealed low value could be associated with dried leaves used for this study. Departed report was observed by Salma (2020) who reported high value of protein (29.36%) in their study of functional and nutritional properties of Moringa. Deviated observation of high value protein (28.08%) was also observed by Bamishaiye *et al.* (2011) and Okiki *et al.* (2015) for *Moringa oleifera* in Ado-Ekiti. Moisture content for this study is very low and may indicate a very high shelf life that can protect the leaves of moringa from attack of microbial spoilage. Similar observation of low value was reported by Okiki *et al.* (2015) while contrary observation was reported Mahima *et al.* (2015) in their study of nutritional potentials of *Moringa oleifera* leaves in India.

CONCLUSION

Moringa Oleifera which comprises of different mineral elements *(*Magnesium and others*)* contributes many to the human body, it helps in building body mineral elements. However, from this study, it was discovered that *Moringa oleifera* containied *high amount of* magnesium which is needed for more than 300 biochemical reactions in the body. It helps to maintain normal nerve and muscle function, supports a healthy immune system, keeps the heartbeat steady, and helps bones remain strong. Lack of magnesium may cause nerve dysfunction and promote mental health conditions. *Moringa oleifera* had high amount of carbohydrate which provide energy, store energy, build macromolecules etc. However, lack of carbohydrate will make level of sugar in blood to drop below the normal range (70-99 mg/dL), causing hypoglycemia. Therefore, this study showed that the *moringa* studied is good for healthy living as at time of this study.

RECOMMENDATION

Based on the findings of this research study; it is recommended that the planting of economical plants which have the nutritional and medicinal values became necessary in our environments, especially plants such as *Moringa oleifera* tree, which is rapidly growing, drought - resistant tree. It is also recommended that *Moringa oleifera* tree should be used as a demarcation plant in our farms, backyard farm gardens so as to have enough access to the plant parts material for provision of quick and safe supply of its nutritional values and health benefits.

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PRODUCTION AND EVALUATION OF AMINO ACIDS AND ANTIOXIDANT PROPERTIES OF BREAD PRODUCED FROM GRAINS, VEGETABLES AND FISH BLENDS

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ABSTRACT
The fortification of food products has been an important tool, not only to manage or prevent specific nutritional deficiencies, but also to promote a general state of well-being in different populations and possibly to prevent certain chronic diseases.. The aim of this work was to evaluate amino acid profile and antioxidant properties of bread produced from wheat, Acha, pumpkin and fish flour blends. Four composite flour blends were formulated in the ratio of A=85:5:0:10, B= 75:10:5:10, C=65:15:10:10, D=100:0:0:0 (wheat, acha, fluted pumpkin and fish). The flour blends were used to produce breads using the straight dough method of AOCC with the recipe with graded levels of wheat flour supplemented. . The result shows significant difference (p<0.05) among thefor the essential and non-essential amino acids. The total essential amino acid values of the samples ranged from 31.99 (sample A) to 44.29 (sample C) g/100g protein. Glutamic acid was found to be the most abundant amino acid and tryptophan was the first limited essential amino acid in this study. Furthermore, The antioxidant activity of formulated samples ranged from 51.99 to 68.22, 0.75 to 1.72 mg/g, 1.02 and 1.72% and 46.06 and 57.07% for (DPPH, FRAP, total Phenol and Fe2+ Chelation respectively. The study concluded that supplementation of acha, fish and fluted pumpkin can be used to improve the nutritional quality of bread especially in developing countries where malnutrition and diabetes is prevalent at all aged group.
Keywords: *Bread, DPPH, amino acids, anti oxidants*

INTRODUCTION
The fortification of food products has been an important tool, not only to manage or prevent specific nutritional deficiencies, but also to promote a general state of well-being in different populations and possibly to prevent certain chronic diseases (Białek *et al*. 2015). The identification and development of fortifying agents that would ensure high product quality and bioavailability pose some technological and scientific challenges (Revathy and Sabitha, 2013)
Diabetes consists of a group of metabolic disorder characterized by elevated blood glucose, either because insulin production is inadequate or because the body's cells do not respond properly, or both. The number of global diabetes cases was 171 million in 2010 and is predicted to rise to 366 million by 2030 (Olagunju *et al*., 2018). Its increasing worldwide incidence constitutes a global health burden. Maintenance of body antioxidant status is important in the management of type 2 diabetes mellitus (Olagunju *et al*., 2018). Currently, the constraint to the use of synthetic inhibitors such as acarbose, voglibose, and miglitol is the exorbitant prices and the associated clinical side effects such as hypoglycemia, weight gain and the non-tolerance by some patients (Dujic *et al*., 2015). Inhibitors derived from natural products do not have side effects, and the therapies are well tolerated. Hence, the increase in the search for food derived natural inhibitors of the key enzymes.
Pumpkin (*Telfairia occidentalis*), a tropical cucurbit (Kiin-kaban *et al*., 2020) is grown in Nigeria as a source of leafy vegetable, and for its oil-bearing seeds. Common names for this plant in Nigeria include 'ugu', and fluted gourd. *Tefairia occidentalis* grows in many countries of West Africa, but cultivated mainly in Nigeria where it is used primarily in soups and herbal medicines. Fluted pumpkin is rich in protein, vitamins and minerals(such as iron reported to be useful in the treatment of anaemia (Adegbenro *et al*., 2020). Consumption of fluted pumpkin leaves and seeds helps in preventing cancer, improves blood count, reduces blood glucose and cholesterol levels (Adegbenro *et al*., 2020).

Fish is valued for providing high quality protein than meat and egg. However, it is one of the most perishable of all the foods due to suitable medium for growth of micro-organisms after death. Catfish (*Clarias spp*) is highly nourishing. It contains lysine, vitamin A, calcium, phosphorus, fat, and other nutrients needed for human growth and health (FAO, 2003). Edible fish meal is the product obtained from the removing of water and oil from whole fish, thereby increasing the concentration of protein and other nutrients (Ibrahim, 2009). Edible fish meal provides the opportunity of utilizing other nutrients such as calcium that are available in the fish.

Acha (Fonio) is the term for two cultivated grains in the *Digitaria* genus which are notable crops in parts of West Africa. The grains are very small. The crops have C4 metabolisms and are medium in height. It has potential to improve nutrition, boost food security, foster rural development, and support sustainable use of the land (Ogori *et al.*, 2020). Fonio grains are considered as the best tasting and nutritious of all grains with about 7% crude protein that is high in leucine (9.8%), methionine (5.6%) and valine (5.8%). The aim of this work was to evaluate amino acid profile and antioxidant properties of bread produced from wheat, Acha, fish and pumpkin flour blends.

MATERIALS AND METHODS

Wheat, Acha and fluted pumpkin leaf were purchased from a local market in Lafia, Nasarawa State, Nigeria. While catfish was purchased from a fish farm in Lafia Nasarawa state. The products were processed at the food laboratory of the Department of Home Science and Management Nasarawa State University, Keffi Shabu-Lafia Campus.

Flour blends was prepared with graded levels of wheat flour supplemented with acha flour, pumpkin and fish. The graded levels ranged from 0 – 10% fish flour, 0 – 10% pumpkin flour 0-10% and 0 – 15 % acha flour, with 100% wheat flour as the control.

Table 1: Flour blend formulation

Food Material	A (%)	B (%)	C (%)	D (%)
Wheat	85	75	65	100
Acha	5	10	15	0
Pumpkin Leaf	0	5	10	0
Fish`	10	10	10	0
Total	100	100	100	100

Production of Experimental Bread

The flour blends were used to produce breads using the straight dough method of AOAC, (2012) The flour blends and other ingredients was mixed manually for 5 minutes. The dough covered with kitchen cloth and placed in the fermentation chamber for 90 minutes at the temperature of 37 ± 2^0C, relative humidity 85%, thereafter it was degassed. The baking pans was greased with fat, the dough pieces (250g) were manually molded and placed into the pans and proofed for 60 minutes and later placed in the pre-heated oven, baked at 200^0C for 30minutes. The loaves of bread were allowed to cool (3-4hours), dried, and grinded into powder form and left in polythene bags for storage.

Amino Acid Profile Determination

The amino acids profiles of the formulated blends were determined using AOAC (2012) method. The data were calculated as grams of amino acid per 100g crude protein of flour sample.

Anti oxidant activity Determination

Antioxidant activity DPHH, FRAP, total phenolic and Fe^{2+} Chelation ability was measured based on the modified methods described by Oboh *et al.,* (2010) and Ijarotimi *et al*., (2022).

Statistical Analysis

All measurements were done in at least two replicates, and the results were subject to one factor analysis of variance (ANOVA), applying software package SPSS 16.0.The significance of differences was evaluated by Duncan's test, at $P<0.05$. The results are represented as mean value ± standard deviation (SD)

RESULTS AND DISCUSSION

The result of the amino acid contents of bread produced from wheat, acha, fish and pumpkin blends are presented in Table 2. The result shows significant difference ($p<0.05$) among the treatments for the essential and non-essential amino acids. The total essential amino acid values of the samples ranged from 31.99 (sample A) to 44.29 (sample C) g/100g protein. These values are significantly higher than the recommended value (30.1g/day) by WHO/ FAO (2004). For the total non-essential amino acids, the values ranged between 46.56 and 54.37 g/100g protein with sample C scoring the highest value. Glutamic acid was found to be the most abundant amino acid and tryptophan was the first limited essential amino acid in this study. The high value for glutamic acid is similar and agree with the report of

Ijarotimi *et al.*, (2019) that the commonly most the predominant amino acid in plant foods is glutamic acid. Evidence have shown that both systolic and diastolic blood pressure is lower by the intake of plant proteins high in amino acids such as glycine, glutamic acid, histidine, cysteine and arginine (Ijarotimi *et al.*,2019).

The result of the antioxidant properties of bread produced from wheat, acha, fish and pumpkin blends are presented in figure 1 to 4. The result shows significant difference ($p<0.05$) was observed in the parameters assessed among the food samples. The antioxidant activity of formulated samples ranged from 51.99 to 68.22, 0.75 to 1.72 mg/g, 1.02 and 1.72% and 46.06 and 57.07% for (DPPH, FRAP, total Phenol and Fe^{2+} Chelation respectively. The higher antioxidant properties recorded in the enriched breads can be attributed to the addition of Telfairia occidentalis (fluted pumpkin), edible fish meal and acha in the bread formulation. This finding could be attributed to variations in food composition and bioactive components like phytochemicals, fibres and bioactive proteins, which were significantly present in the formulated food samples, especially in Telfairia occidentalis leaf. According to Oboh *et al.*, (2010),Telfairia occidentalis possess antioxidant property. This findings also agreed with the report of Ijarotimi *et al.*, (2022) and David *et al.*, (2022).

Table 2: Amino acids profile (g/ 100 g of protein) of Bread produced wheat, acha, fish and pumpkin blends

Amino Acids	A	B	C	D	* RVAdult	* RV Children
Non-Essential Amino Acids (NEAAs)						
Glycine	3.87^b	3.21^d	3.73^c	4.02^a	-	-
Alanine	3.72^b	2.39^d	3.44^c	4.06^a	-	-
Serine	3.81^c	4.00^b	4.36^a	3.51^d	-	-
Proline	4.01^d	4.06^c	4.22^a	4.09^b	-	-
Aspartic	6.92^d	7.84^b	8.05^a	7.03^c	-	-
Cysteine	1.22^c	1.28^b	1.64^a	0.83^d	-	-
Glutamic	12.67^d	14.51^b	15.18^a	13.51^c	-	-
Tyrosine	3.63^d	3.73^b	3.97^a	3.66^c	-	-
Arginine	6.71^d	8.92^b	9.78^a	7.64^c	-	-
∑NEAAs	$\mathbf{46.56^d}$	$\mathbf{49.94^b}$	$\mathbf{54.37^a}$	$\mathbf{48.35^c}$	-	-
Essential Amino Acids (EAAs)						
Phenylalanine	4.11^c	4.01^d	4.43^a	4.21^b	2.5	6.90
Histidine	2.15^d	2.31^b	2.47^a	2.27^c	-	1.00
Methionine	2.69^c	3.74^b	4.04^a	1.78^d	1.5	2.70
Valine	6.26^c	9.67^b	10.31^a	5.67^d	2.6	3.80
Tryptophan	0.98^d	1.99^b	2.32^a	1.01^c	0.4	1.25
Threonine	2.64^d	3.41^b	3.72^a	3.31^c	1.5	3.70
Isoleucine	4.32^d	6.77^b	6.81^a	4.58^c	2	3.10
Leucine	4.51^c	4.31^d	5.01^a	4.72^b	3.9	7.30
Lysine	4.33^d	5.03^b	5.18^a	4.55^c	3	6.40
∑EAAs	31.99^d	41.24^b	44.29^a	32.1^c	-	-
TAAs	78.55^d	91.18^b	98.66^a	80.45^c	-	-
Predicted Nutritional Qualities						
∑SAA(Meth+Cys)	3.91	5.02	5.68	2.61		
∑ArAA(Phe+Tyr)	7.74	7.74	8.40	7.87		
∑BCAA(Val+Isol+Leu)	15.09	20.75	22.13	14.97		
Lysine/Arginine	0.65	0.56	0.53	0.60		

Mean values with the diferent superscript within the same row are signifcantly diferent from each other ($p\leq0.05$),A=wheat 85% acha 5%: fluted pumpkin 0%: fish 10%, B= wheat 75%: acha 10%: fluted pumpkin 5%: fish 10%, C = wheat 65%: acha 15%: fluted pumpkin 10%: fish 10%, D = wheat 100%: acha 0%: fluted pumpkin 0%:

fish 0 % . BCAAs=Branch chain amino acids (Valine + Isoleucine + leucine); ArEAA=Aromatic amino acids (Phenylalanine+Tyrosine); TSAA=Sulphur containing amino acids (Methionine+Cysteine); *RV (WHO/FAO 2004)

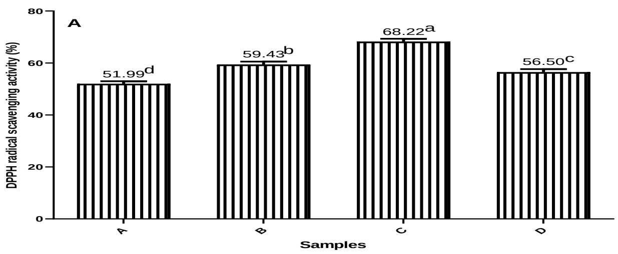

Figure 1: DPPH

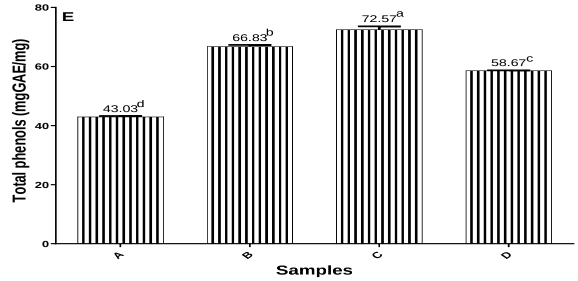

Figure 2: Total Phenols Content

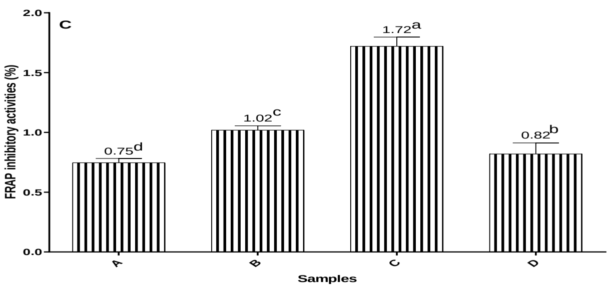

Figure 3: FRAP Inhibitory Activities

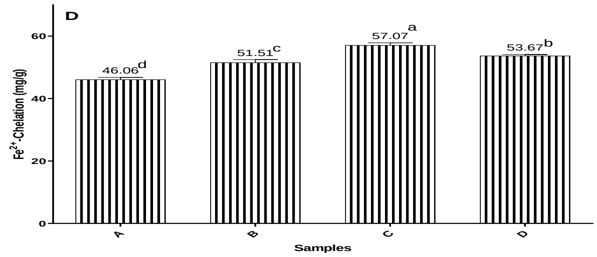

Figure 4:Fe^{2+} Chelation Ability

Fig1-4 Antioxidant Properties of Bread Produced from Wheat, Acha, Fish and Pumpkin Blends.*Bars with different alphabetical superscripts are significantly different at P<0.05*

CONCLUSION

This work has shown that the incorporation of acha, fluted pumpkin and fish wheat in production of bread would result in products of high nutritional quality for the populace. Significant increase was observed in terms of the amino acid profile (essential and non-essential amino acids) and antioxidant activities of the bread which may be good in the management of Diabetes Mellitus.

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RESPONSE OF ORANGE-FLESHED SWEET POTATO TO NPK-ENRICHED RICE MILL WASTE (BRAN) FORMS FOR COMMERCIAL SWEET POTATO PRODUCTION

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ABSTRACT
The potential contribution of orange-fleshed sweet potato towards food security in Nigeria is underestimated as a huge gap due to the soil environment as an important yield determinant. The research into the soil nutrient conditions for sweet potato production has not been extensive. The study was conducted in the 2020 and 2021cropping seasons at the Eastern farm of National Root Crops Research Institute, Umudike, Abia State. The experiments was a 4 x 2 x 2 factorial experiment laid out in Randomized Complete Block Design (RCBD). NPK 15:15:15 at levels of 0, 200, 400 and 600 kg/ha with carbonize RMW at 0 and 5 t/ha and uncarbonize RMW at 0 and 10 t/ha giving a total of 16 treatment combinations replicated three times. The rice mill wastes were applied to the plots two weeks before planting. Mineral fertilizer was applied at 4 weeks after planting. The test crop orange-fleshed sweet potato, UMUSPO/3 variety (Mother's Delight) was obtained from Sweet potato Research Programme of NRCRI, Umudike. Data were collected on yield performance, total root weight, weight of marketable roots, number of marketable roots and other useful agronomic traits. The analysis was done following the procedures for randomized complete block design (RCBD) using the Genstat Discovery 12th edition Significant treatment means were separated using least significant difference (LSD) at 5% probability level. The result shows that there were significant (P<0.050 difference among the treatments used. The study also shows that integrated nutrient management (combining organic and mineral fertilizers) holds the key to improving the growth and root yield of orange-fleshed sweet potato. The application of rice mill waste had varied effects on the chemical properties of the soil as its application improved the growth parameters at different sampling periods as well as an increase in both the total and marketable root yield of orange-fleshed sweet potato. Based on the findings reported in this study, orange-fleshed sweet potato for commercial root production in the study area can be improved by combining organic materials such as rice mill waste (barn) with mineral fertilizers.
Keywords: *Orange-flesh Sweet potato, NPK 15:15:15, Rice mill waste,*

INTRODUCTION
Root and tuber crops are important sources of carbohydrate for millions of people throughout the tropics. Sweetpotato (*Ipomoea batatas (L) Lam),* a trailing perennial plant of the family Convolvulaceae (morning glory family), and the only member of the genus *Ipomoea* whose roots are edible, is undeniably one of the world's most important food crops due to its high nutritive value (França and Ritschel, 2002). It is believed to have originated from either Central America or within the tropical region of North Western parts of Central America (Onwueme, 1978; Hahn and Hozyo, 1984). It is one of the major root crops that had suffered neglect in the past but now appears to be gaining a prime position as a source of food and industrial raw materials. Globally, sweet potato ranks third among root and tuber crops after potato (281 million tonnes) and cassava (164 million tonnes), with a production of about 122 million tonnes (FAO, 1996). China accounts for the highest production of sweet potato (2,883,408 tonnes) making Asia the world's leading producer of sweet potato (FAO, 2012), followed by Uganda and then Nigeria in that order (FAO, 2004). In Nigeria, it is one of the four major root and tuber crops coming after cassava, yam and cocoyam (FAO, 2018). These crops play important roles in both social and economic development of the country.

The potential contribution of this crop towards food security in Nigeria is underestimated as a huge gap exists between its potential yield of 20 - 40t/ha and actual yield of 3 - 5t/ha in farmers' fields (Wabanechi, 2014). The constraints responsible for farmer's low yields could be as a result of weed competition and poor soil management (Atnafu, 2019).

Research into the soil nutrient conditions for sweet potato production has not been extensive. This may have been due to the notion that sweet potato is adapted to soil acidity and it is deep-rooting, with the ability to produce fairly good yield from poor soils. (Thorup-Kristensen and Kirkegaard, 2016).

The current revolution in the production of rice by the Federal government which has led to a sporadic rise in rice production in South-east Nigeria has made rice mill waste abundant. This organic material can be carbonized through the use of a carbonator machine and incorporated to the soil to increase soil fertility, increase agricultural productivity and provide protection against some soil acidity, foliar and soil-borne diseases (Warnock *et al.*, 2007). It serves as an alternative organic fertilizer additionally with NPK fertilizer for sustainable crop production in the agricultural sector have remarkable agronomic values and yield potential in poor degraded soils (Lashari *et al.,* 2013).

In response to this challenge, the objective of this study is to determine the response of orange-fleshed sweet potato to NPK-enriched rice mill waste (bran) forms for commercial sweet potato production.

MATERIALS AND METHODS

The study was conducted in the 2020 and 2021cropping seasons at the Eastern farm of National Root Crops Research Institute, Umudike, Abia State. Abia State is one of the states in the rain forest zone of the Southeastern geopolitical zone of Nigeria. The other states within the region include Anambra, Ebonyi, Enugu, and Imo. It lies within Latitude 4°15ʹ and 7°N and Longitude 5°29° North and 7°33ʹ east of the Equator with an elevation of 122m above sea level. It is therefore heated by the vertical rays of the sun all year round.

The land was slashed, ploughed, harrowed and ridged mechanically and the field was demarcated into plots and replicates. The experiment was a 4 x 2 x 2 factorial experiment laid out in Randomized Complete Block Design (RCBD). The plot size measured 3m x 3m with 0.5m space separating the plots and 1m space separating the replications. The materials for the experiment were mineral fertilizer (NPK15:15:15), carbonized rice mill waste and uncarbonized rice mill waste. NPK 15:15:15 at levels of 0, 200, 400 and 600 kg/ha was factorially combined with carbonize RMW at 0 and 5 t/ha and uncarbonize RMW at 0 and 10 t/ha giving a total of 16 treatment combinations replicated three times. The rice mill wastes were applied to the plots two weeks before planting. The sweet potato vine cuttings were planted on the crest of the ridge at a spacing of 0.3m within rows and 1m between rows giving a plant population of 33.333 stands/ha and the mineral fertilizer was applied at 4 weeks after planting.

All the data collected were subjected to analysis of variance, using the Genstat Discovery 12th edition (Genstat, 2009). Significant treatment means were separated using least significant difference (LSD) at 5% probability level according to Obi (2001).

RESULTS

Table 1 result shows that the application of NPK-fertilizer at 400 kg/ha on fresh total root yield weight of orange-fleshed sweet potato, recorded the highest (16.82 and 15.28 t/ha) total root yield weight compared to other rates of NPK -fertilizer application in 2020 and 2021 cropping seasons. The application of CRMW and UCRMW also recorded an increase in the total root yield weight (15.28 t/ha and 16.59 t/ha) in 2020 and 2021 (6.15 and 6.41 t/ha) cropping season respectively. However the application of NPK -fertilizer at 400 kg/ha x 5 t/ha of CRMW recorded the highest total of root yield weight (19.09 and 7.43 t/ha) in both cropping season throughout the year of observation.

A significant difference ($P<0.05$) was observed in the interaction between NPK-fertilizer x URMW in 2020 cropping season as well in the interactions between CRMW x URMW for both 2020 and 2021 cropping seasons. No significant difference ($P>0.05$) was observed in the interaction between NPK -fertilizer x CRMW in both 2020 and 2021 cropping seasons.

Table 1 result shows that the application of NPK-fertilizer at 400 kg/ha showed superiority over the others In both planting season,, giving a marketable root yield weight of 13.87 and 5.28 kg/plant, followed by the application of 600 kg/ha that gave 13.47 and 4.47 kg/plant while the control had the least of 8.12 and 3.81 kg/plant respectively. Both cropping seasons in 2020 and 2021 respectively, recorded an increase in the weight of marketable roots with the application of CRMW and URMW. The weight of unmarketable root yield of orange-fleshed sweet potato in 2020 and 2021 cropping seasons in Table 1, shows no significant difference ($P>0.05$) in the 2-way interaction: NPK - fertilizer x CRMW; NPK-fertilizer x URMW and CRMW x URMW, but the application of NPK-fertilizer at 400 kg/ha produced the highest unmarketable root weight of 1.275 kg/plant in 2020 cropping season while the application of 200 kg/ha of NPK-fertilizer produced the highest unmarketable root weight of 1.39 kg/plant in 2021 cropping season. Application of CRMW and that of URMW did not produce any effect on the unmarketable root weight in 2020 cropping season but did so in 2021.

Table 1 result revealed no significant differences ($P>0.05$) among the treatments that were applied in 2020 and 2021 planting seasons respectively. However the application of NPK-fertilizer at 400 kg/ha produced the highest number of marketable roots of 47.4 and 23.8 roots/plant respectively in the two years. The application of RMW forms also increased the number of marketable roots in the two years. The results shows a significant difference ($P<0.05$) only on the interaction between NPK-fertilizer x URMW in 2020 cropping season while the rest of sampled parameters did not show any significant difference both in 2020 and 2021 cropping seasons.

Table 1: Effect of NPK-enriched rice mill waste forms on root yield attributes of orange-fleshed sweet potato in 2020 and 2021 cropping seasons

Treatment	2020 Number of marketable roots/plant	2020 Number of unmarketable roots/plant	2020 Weight of marketable roots/plant (kg)	2020 Weight of unmarketable roots/plant (kg)	2020 Fresh root yield (t/ha)	2021 Number of marketable roots/plant	2021 Number of unmarketable roots/plant	2021 Weight of marketable roots/plant (kg)	2021 Weight of unmarketable roots/plant (kg)	2021 Fresh root yield (t/ha)
Fertilizer (NPK)										
0	30.5	25.7	8.12	1.04	10.32	19.9	11.2	3.81	0.64	4.86
200	43.2	22.4	11.43	1.13	13.77	17.9	10.8	3.52	1.39	4.56
400	47.4	26.0	13.87	1.28	16.82	23.8	14.8	5.28	0.83	6.80
600	42.0	26.4	13.47	1.21	15.38	21.0	16.0	4.47	0.84	5.72
$LSD_{(0.05)}$	12.27	8.31	3.298	0.3849	3.834	9.87	6.20	1.043	1.210	2.515
Carbonized rice mill waste (C)										
0	36.6	24.5	10.40	1.19	12.87	18.5	11.2	3.69	1.17	4.82
5	45.0	25.8	13.04	1.17	15.28	22.8	15.2	4.86	0.68	6.15
$LSD_{(0.05)}$	8.67	5.88	2.332	0.2722	2.711	6.98	4.39	0.738	0.855	1.778
Un-carbonized rice mill waste (U)										
0	35.4	24.6	9.64	1.19	11.56	18.5	13.3	3.54	1.09	4.56
10	46.1	25.6	13.80	1.17	16.59	22.8	13.1	5.00	0.77	6.41
$LSD_{(0.05)}$	8.67	5.88	2.332	0.2722	2.711	6.98	4.39	0.738	0.855	1.778
NPK × C										
0 × 0	21.8	24.8	6.10	1.22	8.09	16.0	8.0	2.97	0.78	4.00
0 × 5	39.2	26.5	10.13	1.17	12.56	23.8	14.3	4.65	0.50	5.72
200 × 0	43.0	22.8	11.68	1.08	14.19	12.7	7.2	2.67	2.15	3.56
200 × 5	43.3	22.0	11.18	1.00	13.35	23.2	14.5	4.38	0.63	5.57
400 × 0	40.8	24.3	11.82	1.28	14.56	25.7	14.7	4.77	0.78	6.17
400 × 5	54.0	27.7	15.92	1.27	19.09	22.0	15.0	5.80	0.88	7.43
600 × 0	40.7	26.0	12.02	1.17	14.56	19.5	15.0	4.35	0.98	5.56
600 × 5	43.3	26.8	14.92	1.25	16.11	22.5	17.0	4.60	0.70	5.89
$LSD_{(0.05)}$	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
NPK × U										
0 × 0	17.5	21.2	4.60	1.033	6.22	15.3	12.8	2.68	0.68	3.57
0 × 10	43.5	30.2	11.63	1.350	14.43	24.5	9.5	4.93	0.60	6.15
200 × 0	42.3	20.8	10.90	1.033	13.26	15.8	9.2	3.33	2.13	4.28
200 × 10	44.0	24.0	11.97	1.050	14.28	20.0	12.5	3.72	0.65	4.85
400 × 0	41.3	24.8	9.98	1.217	12.44	24.8	17.3	4.38	0.73	5.69
400 × 10	53.5	27.2	17.75	1.333	21.20	22.8	12.3	6.18	0.93	7.91
600 × 0	40.5	31.7	13.07	1.467	14.30	18.2	14.0	3.77	0.80	4.70
600 × 10	43.5	21.2	13.87	0.950	16.46	23.8	18.0	5.18	0.88	6.74
$LSD_{(0.05)}$	NS	11.75	4.664	NS	5.423	NS	NS	NS	NS	NS
C × U										
0 × 0	30.9	22.7	8.52	1.108	10.68	13.8	10.6	2.89	1.62	3.84
0 × 10	42.2	26.3	12.29	1.267	15.06	23.2	11.8	4.48	0.73	5.80
5 × 0	39.9	26.6	10.76	1.267	12.44	23.3	16.1	4.19	0.56	5.28
5 × 10	50.0	24.9	15.32	1.075	18.12	22.4	14.3	5.52	0.80	7.03
$LSD_{(0.05)}$	NS	NS	NS	NS	NS	2.29	NS	NS	NS	NS

RESULT OF THE TREATMENT INTERACTION

The 3-way interaction between NPK-fertilizer × carbonized rice mill waste × un-carbonized rice mill waste effects on yield and yield components of orange-fleshed sweet potato in 2020 and 2021 cropping seasons is represented in Table 2. The number of marketable roots per plant did not show any significant differences (P>0.05) in both cropping seasons. However the application of NPK-fertilizer r at 400 kg/ha x 5 t/ha CRMW x 10 t/ha URMW gave the highest number of marketable roots/plant in 2020 cropping season, while the application of NPK-fertilizer at 600 kg/ha x 5 t/ha CRMW x 10 t/ha URMW gave the highest in 2021 cropping season. Significant differences (P<0.05) were recorded in the number of unmarketable roots per plant in 2020 cropping season with the application NPK-fertilizer at 0 kg/ha x 5 t/ha CRMW x 10 t/ha URMW having the highest number of 33.7 roots. No significant differences ($P>0.05$) were recorded in the number of unmarketable roots per plant in 2021 cropping season. Moreover, both weight of marketable roots per plant, weight of unmarketable roots per plant and total root yield did not record any significant differences ($P>0.05$) in the both years of the experiment.

The results of the combined analysis of variance of yield and yield attributes of orange-fleshed sweet potato across 2020 and 2021 cropping seasons are represented in Table 3. The analysis of variance indicated no significant differences ($P>0.05$) among the yield parameters measured. However, the results obtained showed good increase in the total root yield from 7.59 t/ha under no NPK-fertilizer (control) to 11.81 t/ha with the application of NPK-fertilizer at 400 kg/ha. The application of CRMW as well as URMW also indicated an

Table 2: Interaction of NPK fertilizer × carbonized rice mill waste × un-carbonized rice mill waste effects on yield and yield components of orange-fleshed sweet potato in 2020 and 2021 cropping seasons

	2020				**2021**			
	Carbonized rice mill waste (t/ha)							
	0		**5**		**0**		**5**	
	Un-carbonized rice mill waste (t/ha)							
Fertilizer (NPK) (kg/ha)	**0**	**10**	**0**	**10**	**0**	**10**	**0**	**10**
	Number of marketable roots/plant							
0	7.70	36.00	27.30	51.00	6.70	25.30	24.00	23.70
200	38.00	48.00	46.70	40.00	5.70	19.70	26.00	20.30
400	35.70	46.00	47.00	61.00	23.70	27.70	26.00	18.00
600	42.30	39.00	38.70	48.00	19.00	20.00	17.30	27.70
$LSD_{(0.05)}$	NS				NS			
	Number of unmarketable roots/plant							
0	23.00	26.70	19.30	33.70	3.59	12.59	8.85	16.26
200	17.00	28.70	24.70	19.30	12.96	15.41	13.56	13.15
400	18.00	30.70	31.70	23.70	11.70	17.41	13.19	25.00
600	32.70	19.30	30.70	23.00	14.44	14.85	14.15	18.07
$LSD_{(0.05)}$	16.62				NS			
	Weight of marketable roots/plant (kg)							
0	2.13	10.07	7.07	13.20	1.03	4.90	4.33	4.97
200	10.70	12.67	11.10	11.27	1.77	3.57	4.90	3.87
400	9.60	14.03	10.37	21.47	4.10	5.43	4.67	6.93
600	11.63	12.40	14.50	15.33	4.67	4.03	2.87	6.33
$LSD_{(0.05)}$	NS				NS			
	Weight of unmarketable roots/plant (kg)							
0	1.17	1.27	0.90	1.43	0.77	0.80	0.60	0.40
200	0.97	1.20	1.10	0.90	3.77	0.53	0.50	0.77
400	0.93	1.63	1.50	1.03	0.80	0.77	0.67	1.10
600	1.37	0.97	1.57	0.93	1.13	0.83	0.47	0.93
$LSD_{(0.05)}$	NS				NS			
	Total root yield (t/ha)							
0	23.0	26.7	19.3	23.7	1.67	6.33	5.48	5.96
200	17.0	28.7	24.7	19.3	2.56	4.56	6.00	5.15
400	18.0	30.7	31.7	33.7	5.44	6.89	5.93	8.93
600	32.7	19.3	30.7	23.0	5.70	5.41	3.70	8.07
$LSD_{(0.05)}$	NS				NS			

DISCUSSION

The highest total root yield obtained with the application of composite manure and mineral fertilizer in this study might be as a result of improvement in the physiochemical properties of the soil which led to the release of nutrients for crop uptake. Similar results were reported by Agyarkor *et al.,* (2014), with incorporation of organic manure and N:P:K fertilizer on sweet potato yield; Akinmutimi, (2014), with the application of cocoa pod husk ash and N:P:K-fertilizer on the yield of sweet potato as well as Onunka *et al*., (2012), with the application of organic and inorganic manure on root yield of sweet potato and Asawalam and Onwudiwe, (2011), with complimentary use of cow dung and mineral fertilizer on sweet potato; Yeng *et al.,* (2012), also reported similar results with the integrated application of chicken manure and inorganic fertilizer on the growth and yield of sweet potato while Ojeniyi *et al.,* (2012), with integrated application of N:P:K fertilizer and poultry manure on cassava. Santhi and Selvakumari (2000), have proposed that the application of organic manure sources to chemical fertilizer could increase the yield of crops through improving soil productivity and higher fertilize use efficiency. Moreover, Ayoola and Makinde (2007), also suggested that an integrated nutrient management programme in which both organic manure and inorganic fertilizer are used is a rational strategy. The combined use of organic manure and inorganic fertilizer will increase synchrony and reduce losses by converting inorganic N into organic forms (Kramer *et al*., 2002). It also reduces the environmental problems that may arise from the use of inorganic fertilizers alone and improve the microbial properties of the soil (Belay *et al*., 2001).

CONCLUSION

It can be concluded that integrated nutrient management (combining organic and mineral fertilizers) holds the key to improving the growth and root yield of orange-fleshed sweet potato. The results showed that application of rice mill waste had varied effects on the chemical properties of the soil as its application showed superiority in improving the growth parameters at different sampling periods as well as an increase in both the total and marketable root yield of orange-fleshed sweet potato.

RECOMMENDATIONS

Based on the findings reported in this study, orange-fleshed sweet potato for commercial root production in the study area can be improved by combining organic materials such as rice mill waste (bran) with mineral fertilizers. This will help in a big way to improve the soil properties and enhance an increase in sweet potato growth and yield.
Consequently,

- ❖ Application of 400kg/ha NPK + 5t/ha CRMW + 10t/ha URMW is recommended for good commercial root production of orange-fleshed sweet potato in the study area
- ❖ For vine multiplication, the application of still 400kg/ha NPK + 5t/ha CRMW + 10t/ha URMW is equally recommended.
- ❖ The economics of using organic and mineral fertilizer sources in crop production should also be part of soil studies in order to balance nutrient input with cost.

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EFFECT OF WILD MANGO SEED (*IRVINGIA GABONENSIS*) OIL ON QUALITY OF STORED CHICKEN EGGS

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ABSTRACT
This research work was to determine the effect of wild mango seed (Irvingia gabonensis) oil on preserving the quality of freshly laid chicken eggs during storage at tropical ambient temperature of 30ºC to 35ºC. A total of 150 freshly laid chicken eggs were used. These eggs were obtained from 25 weeks old Black Harco layers at the University of Ilorin School Farm. The layers were fed diets that contain 3.75% calcium and 16.50% protein, divided into five (5) groups including the control. The eggs were treated with the treatment oil within 24 hours of lay. The results showed a significance difference (p<0.05) between treatments with respect to shell strength, Haugh unit, yolk index, and albumen pH of eggs. The wild mango seed (WMF) treatment has shell strength of 1.094, Haugh unit 64.15, yolk index(0.52) and albumen pH (8.90) being the highest values and significantly different (p<0.05) from other treatments. The other treatments were: Palm kernel oil (PKO) with shell strength of 1.084, Haugh unit 54.30, yolk index 0.43 and albumen pH of 8.90. Groundnut oil (GNO) with shell strength of 1.083, Haugh unit 55.20, yolk index 0.42 and albumen pH of 8.90. Shea butter fat (SBF) with, shell strength of 1.082, Haugh unit 53.50, yolk index 0.40 and albumen pH of 8.85. And control, shell strength of 1.0162, Haugh unit 35.60, yolk index 0.16 and albumen pH of 10.12. However, all treatments showed a significant difference with the control in respect to decline in shell strength, Haugh unit and yolk index and increase in albumen pH values. Also wild mango seed fat treatment was found to be the most effective in maintaining the shell strength, Haugh unit and yolk index. And the values were significantly different from all the treatments.
Keyword: *Shea butter fat, wild mango fat, palm kernel oil, groundnut oil, shell Coating, shell strength, Haugh unit, yolk index and albumen pH*

INTRODUCTION
Protein mal-nourishment is a problem among many people in the world especially in the developing countries like Nigeria. The chicken eggs help to supply this protein but these eggs have the challenge of deterioration (Shittu and Ogunjinmi,2011) These eggs start to deteriorate from the day they are laid, (Nongtaodun,2013). The chicken eggs undergo significant physical, chemical, structural and physiological changes during storage,(Okiki and Ahmed,2017). These eggs have to be preserved using many methods. One of this method is coating of eggs using fat and oil. The egg shell that covered the albumen and the egg yolk are structured with the, pores on the shell and albumen and yolk are inside the egg.The carbon dioxide help to preserve the albumen and the yolk from deterioration by micro organisms. (Nongtaodun, 2013), Ryu *et al.*, 2011). Also the carbon dioxide help to provide a continuously cool environment hence preserve the chicken eggs.

Many researchers have used fat and oil to coat eggs in order to preserve them. But the use of wild mango seed oil: *irvingia gabonensis* to coat and preserve chicken eggs is not common. The wild mango seed oil was extracted from wild mango seeds using the soxhlet extractor apparatus.The coating of chicken eggs with wild mango fat and other fat and oil sealed the egg shell pores to prevent evaporation of water vapour and carbon dioxide, this led to the preservation of the egg. The vegetable oil were used for coating of chicken eggs to preserve them. (Ryu et al 2011) and (Enefola et al 2022). During the storage mass losses of weight for control treatment were in agreement with those reported by (Hasan Akyurek *et al*., 2009).

The weight loss in the chicken egg in storage occur through evaporation, and this depend on the storage time, temperature, carbon dioxide, relative humidity and shell porosity. (Naheed *et al.,* 2014), (Almeida *et al*., (2016), (Ryu *et al*., 2011), and (Zhang *et al*., 2016), and (Wengerska *et al.,* 2023).

MATERIALS AND METHODS

Source of Sample

Freshly laid eggs were collected from University of Ilorin School Poultry Farm. The other oil and fat were bought from Oja oba Market. But the wild mango seed oil was extracted in the laboratory using the Soxhlet extractor apparatus.

Treatment of samples

The test eggs were produced by Black Harco layers. The eggs were purchased and treated with fat and oil freshly laid. Eggs were marked for identification purpose during the course of the experiment. The shell strength, Haugh unit, yolk index and the albumen pH of the chicken egg were determined.

Statistical Analysis

Data were subjected to analysis of variance and significant difference between means were accessed by applying Duncan's multiple range test. (Duncan 1955)

RESULTS AND DISCUSSION

Table 1 shows the effect of storage treatment on the egg shell strength. The wild mango seed oil treatment showed the highest shell strength of 1.094 at the end of 35 days in storage. Other treatments were in this order, palm kernel oil (1.084), Groundnut oil (1.083), shea butter oil 1.082 and the control was 1.0162.The results showed significant differences ($p< 0.05$) between the treatments and the control.

Table 2 shows the effect of storage treatment on the Haugh unit. The wild mango seed oil treatment has the highest Haugh unit of 64.15 at the end of 35 days in storage. The Haugh unit values for other treatments were palm kernel oil 54.30, groundnut oil 54.30 and shea butter oil 53.50, and control 35.60. The results showed significant differences ($p< 0.05$) between the treatments and the control.

Table 3 showed the effect of storage treatment on the yolk index value. The wild mango seed oil showed the highest yolk index value 0.52 at the end of 35 days in storage. The other treatments yolk index values were in this order, palm kernel oil 0,43, Groundnut oil 0.42 and Shea butter oil 0.40. and control 0.16. The results showed significant differences ($p< 0.05$) between the treatments and the control.

From table 4, the effect of storage treatment on the albumen pH. The four treatment have equal values of the albumen pH. The wild mango seed oil 8.90, palm kernel oil 8.90, Groundnut oil 8.90, shea butter oil 8.90 and control was 10.12. The results showed significant differences ($p< 0.05$) between the treatments and the control.

From table 5, the wild mango seed oil showed a significant difference ($p< 0.05$) with other treatments

Table 1; The effect of storage on (shell strength) of chicken eggs

	Duration of storage (days)					
Parameter	0	7	14	21	28	35
Wild mango seed oil	1.0912	1.0902	1.0920	1.0930	1.0935	1.0940
Palm kernel oil	1.0911	1.0910	1.0890	1.0880	1.0860	1.0840
Groundnut oil	1.0911	1.0890	1.0880	1.0870	1.0850	1.0830
Shea butter oil	1.0912	1.0910	1.0900	1.0890	1.0870	1.0820
Control	1.0911	1.0811	1.0512	1.0310	1.0190	1.0162

Table 2; The effect of storage treatment on Haugh unit of chicken egg

Parameter	Duration of storage (days) 0	7	14	21	28	35
Wild mango seed oil	80.40	76.10	72.11	70.10	67.12	64.15
Palm kernel oil	80.20	75.30	71.40	64.20	61.50	54.30
Groundnut oil	80.50	77.20	72.10	61.50	60.10	56.30
Shea butter oil	81.10	75.50	71.50	68.10	59.20	53.50
Control	81.20	65.10	62.30	58.20	36.60	35.60

Table 3; The effect of storage on yolk index of chicken egg

Parameter	Duration of storage (days) 0	7	14	21	28	35
Wild mango seed oil	0.56	0.55	0.54	0.53	0.52	0.52
Palm kernel oil	0.55	0.54	0.48	0.45	0.44	0.43
Groundnut oil	0.56	0.52	0.49	0.46	0.43	0.42
Shea butter oil	0.55	0.53	0.47	0.43	0.42	0.40
Control	0.55	0.42	0.40	0.38	0.30	0.10

Table 4; The effect of storage on albumen PH of chicken egg

Parameter	Duration of storage (days) 0	7	14	21	28	35
Wild mango seed oil	8.15	8.20	8.30	8.40	8.50	8.90
Palm kernel oil	8.10	8.28	8.40	8.44	8.60	8.90
Groundnut oil	8.15	8.20	8.45	8.50	8.55	8.90
Shea butter oil	8.10	8.33	8.38	8.51	8.57	8.90
Control	8.10	9.12	9.32	9.39	9.45	10.12

Table 5; The effect of storage on shell strength, Haugh unit, yolk index and albumen pH of chicken egg

Parameter	shell strength	Haugh unit	yolk index	albumen
Wild mango seed oil	1.094^{c}	64.15^{c}	0.52^{c}	8.90^{c}
Palm kernel oil	1.084^{b}	54.30^{b}	0.43^{b}	8.90^{b}
Groundnut oil	1.083^{b}	55.20^{b}	0.42^{b}	8.90^{b}
Shea butter oil	1.082^{b}	53.50^{b}	0.40^{b}	8.85^{b}
Control	1.0162^{a}	35.60^{a}	0.16^{a}	10.12^{a}

RECOMMENDATIONS AND CONCLUSION

This research work has showed that the wild mango seed oil and other oil and fat rubbed on a freshly laid chicken eggs was efficient in preserving the internal and external quality of the eggs for over one month at room temperature of 30ºC to 35ºC.

It is recommended that the wild mango seed oil should be used in coating chicken eggs to preserve the quality for at least 35 days in storage.

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EVALUATION OF THE PROXIMATE ANALYSIS OF KEBAB MEAT 'SUYA' USING THREE ANIMAL PRODUCTS: BEEF, CHICKEN AND FISH

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ABSTRACT
The study focused on the Evaluation of the Proximate Analysis of Prepared Meat Suya using three Animal Products such as Beef, Chicken and Fish. The moisture, crude protein, carbohydrate, ash, fiber and fat content of the animal product that made up of the prepared meat suya were analyzed using standard methods. The Result of the findings shows the moisture content of the types of suya has the Result ranges of 7.20-9.20%. Fish suya constitute the high value of moisture contents of 9.20%. The relationship between the Ash content of the types of suya has the Result range of 4.20-4.40%. The ash content is often regarded as an index of mineral content in biological mass. However, the relationship between the protein content of the suya has the result range of 10.0-11.0%. Fish suya constitute the high value of protein contents of 11.00%. The Result of the findings shows the crude fibre content of the types of suya has the result range of 13.30-16.40%. Beef suya constitute the high value of crude fibre contents of 16.40%. Crude fiber is a diet component that aids bowel movement and it is relevant in digestion as this promotes better absorption of food into the body. The Result of the findings shows the crude fat content of the types of suya has the result range of 13.30-14.90%. Chicken suya constitute the high value of crude fibre contents of 16.90%. It was recommended that For health benefit, patients who are anaemia in nature are recommended to eat fish and chicken suya which have high protein content (Amino acids) and that form part of the hemoglobin of the blood. Similarly, Patients with hypertensive condition, can make a choice of the meat suya which are very low in fat contents as this, fat itself is an indicators of the weight of the body and the heart.
Keywords: *Suya, Beef, Chicken, Fishes and Spices*

INTRODUCTION
Suya is a spiced, barbecued, smoked or roasted meat product, prepared basically from meat of animals. In developing countries like Nigeria, protein intake has been a cause of concern and suya has become a major source of protein in Nigeria. (Ngozi N.A 2017).

Suya is a spicy, traditional stick meat product that is commonly produced by the Hausas in Northern Nigeria from beef. Where rearing of cattle are an important pre-occupation and major source of livelihood for the people. (Adeniyi M.D., 2016).This leads to the production of ready -to-eat beef products such as suya, kilishi, balangu and kundi. suya is however the most popular as its consumption has extended to other part of the country. According to Effiong G.S. (2010), Suya is a popular, traditionally processed, ready to eat Nigerian meat product, which may be served or sold along the streets, in club houses, at picnics, parties, restaurants and within institutions. It is a mass consumer fast food. Its preparation and sales along the streets are usually not done under strict hygienic condition because they are still done locally with crude tools. (Dagem., D. G , 2010).Traditionally, processed meat products were produced and consumed in different countries throughout the world. According to Edem C.A and I.D. Miranda (2011), Meat is a highly perishable food product, just like milk as described by which unless correctly stored, processed, packaged and distributed may spoil quickly and become hazardous to consumers due to microbial growth. (Armand, Y.N., 2012). The objective of this study is to examine the Proximate Analysis of Prepared Meat Suya using three Animal Products such as Beef, Chicken and Fish.

MATERIALS AND METHODS

Materials

The meat products are Beef, Chicken and Fishes and as well as the Ginger, garlic, West African black pepper, hot pepper and groundnut oils and as well as the respective laboratory analytical instruments

Source of Sample

The meat products and the Suya spices were purchased from lokoja market center, lokoja, capital of kogi State, Nigeria. All reagents and chemicals used were of Analytical grade. Samples were taken to the laboratory immediately and analysed immediately after collected.

Chemical Analysis

The proximate configuration (ash, crude protein, moisture, crude fiber and crude fat) of suya were determined as described by AOAC methods. Carbohydrates were determined by the percentage difference in sum of other proximate parameters (ash, crude protein, moisture, crude fiber and crude fat from 100) as described by AOAC (2010)

Statistical Analysis

Data obtained from the proximate analysis were analyzed using the single factor analysis of variance (ANOVA). Correlations between each of the parameter from each Animal product were evaluated. Also correlations between same parameters from the three study meat Suya were equally compared.

RESULTS AND DISCUSSION

Table 1: The Chemical Composition of the Animal meat products samples

The Table 1 shows the chemical composition of the three Animal meat products samples (Beef, chicken and fish) are;

	BEEF	CHICKEN	FISHES
Carbohydrate (%)	$47.70^{a}\pm0.20$	$49.00^{a}\pm0.50$	$47.50^{a}\pm0.30$
Crude Protein (%)	$10.90^{b}\pm0.40$	$10.00^{b}\pm0.20$	$11.00^{b}\pm0.20$
Crude Fat (%)	$13.30^{c}\pm0.60$		
Crude Ash (%)	$4.40^{c}\pm0.15$		
Crude Moisture (%)	$7.30^{c}\pm0.40$	$7.20^{d}b\pm0.50$	$9.20^{c}\pm0.20$
Crude Fiber (%)	$16.40^{c}\pm0.60$	$14.70^{c}\pm0.80$	$13.30^{d}\pm0.10$

DISCUSSION

Low moisture contents below 10% with significant differences were observed for all brands of animal products of suya in Table 1 above. The moisture, crude protein, carbohydrate, ash, fiber and fat content of the animal product that made up of the prepared meat suya were analyzed using standard methods. The Result of the findings shows the moisture content of the types of suya with the range of 7.20-9.20%. Fish suya constitute the high value of moisture contents of 9.20%. According to Adeniyi M.D. (2016), he stated that, the low moisture levels may suggested that they might be less prone to microbial attack. Effiong G.S. (2010), reported that levels of moisture content give meaning to the presence of microbes in foods. The moisture content of any food is an index of its water activity and is used as a measure of the stability and susceptibility to microbial contamination. The relationship between the Ash content of the types of suya has the result range of 4.20-4.40%. The ash content is often regarded as an index of mineral content in biological mass. Ash constitutes the inorganic component of food and this provides us with an estimate of the mineral constituents of the food. (Dagem., D. G, 2010), However, the relationship between the protein content of the suya has the result range of 10.0-11.0%. Fish suya constitute the high value of protein contents of 11.00%. According to Ngozi N.A .(2017), she stated that Protein are required for body building, renewal of body cells and a host of other physiologic functions, as such, its relevance cannot be over-emphasized. It was reported by Harold, SK (2018) similar values of the protein content of beef meat made up of suya. The Result of the findings shows the crude fibre content of the types of suya with the result range of 13.30-16.50%. Beef suya constitute the high value of crude fibre contents of 16.50%. Crude fibre is a diet component that aids bowel movement and it is relevant in digestion as this promotes better absorption of food into the body. (Armand., Y.N., 2012). The Result of the findings shows the crude fat content of the types of suya with the range of 13.30-14.90%. Chicken suya constitute the high value of crude fibre contents of 16.90%.

CONCLUSION

For health benefit, patients who are anaemia in nature are recommended to eat fish and chicken suya which have high protein content (Amino acids) and that form part of the hemoglobin of the blood. Variable Blood ABO group patients can make a choice of the meat suya which do not have effects on their blood clotting system. Similarly, Patients with hypertensive condition, can make a choice of the meat suya which are very low in fat contents as this, fat itself is an indicators of the weight of the body and the heart. Conclusively, Animal products consumption serves as a pivot to good healthy living among people in the society at large,

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SUPPLEMENTING RATIONS WITH PRO-VITAMIN "A" CASSAVA LEAF MEAL TO IMPROVE JAPANESE QUAIL EGGS YOLK COLOUR

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ABSTRACT
In order to evaluate the effect of cassava leaf meal as supplement in commercial concentrate diets on yolk colour of quail eggs, a trial was carried out in National Root Crops Research Institute, Umudike Poultry Unit for four months. The design was a completely randomized layout with two hundred and forty Japanese quail hens at twenty-one days, allocated to four different diets and three replicates. The treatments were: a commercial concentrate (CC); CC with 3% YRCLM (YRCLM3) and CC + 5% cassava leaf meal (YRCLM5). The degree of yellowness of yolks on the diet supplemented with 5% CLM was higher than for the control diet. The eggs from birds in the treatment with 5% CLM had darker and more chromatic yellow yolks than in the control treatment. The yolks of the Japanese quails supplemented with 5% CLM were heavier than the control treatments. The ratio between the weight of yolk and white was significantly higher in the diet with 5% cassava leaves meal than the control diet. Mean weight of Japanese quail eggs given the diet with 5% cassava leaves meal was significantly higher than for the other treatments as was laying rate and feed conversion.
Key words: *Quail eggs, yolk colour, cassava leaf meal.*

INTRODUCTION
Animal production in developing countries such as Nigeria is faced with various challenges mostly during the dry season of the year. The problem of feed shortage, high prices of feedstuffs and climate variation have been a major discussion in recent times (Agbabiaka, 2012) among poultry farmers. The effect of these challenges has reflection on the quality and quantity of animal protein available for human consumption (Agbabiaka, 2012; Ogbonna *et al*., 2000). To overcome some of these problems, attention of animal nutritionist must be focused on the utilization of lesser known unconventional feedstuffs that are readily available without stiff competition with humans and agro-allied industries such as cassava leaf meal.

Although there have been many studies carried out on the use of cassava products for livestock, little or no information is available on the effect of including them in diets for Japanese quails. The crude protein of cassava leaves can be as high as 350 g/kg of DM which under tropical conditions proved to be useful in diets for growing pigs to improve the dietary protein supply (Phuc *et al*., 2001).

Cassava leaves as food are a good source of protein, vitamins and minerals (Nassar and Marques, 2006). Cassava leaves contain significant amount of carotenoids, especially all-trans-beta carotene, a vitamin A precursor (Chavez *et al*., 2000). Vitamin A deficiency is a public health problem, which can lead to impaired ocular and immune systems growth and development, epithelial cellular integrity and reproductive functions (Wiseman *et al.*, 2017). Hence, increased use of cassava leaves may contribute to reducing vitamin A deficiency. Another important carotenoid present in cassava leaves is Lutein, which has an antioxidant potential (Ma and Lin, 2010).The objective of this experiment was to determine the effect of cassava leaf meal as feed supplement on the colour of the yolks in Japanese quail eggs.

MATERIAL AND METHODS

Experimental design

The study was conducted with one hundred and twenty Japanese quails at 21 days of age and lasted until the end of the fifth week of lay. The quails were allocated in a completely randomized design with three treatments and three replications. The dietary treatments were:

CC: Control (commercial concentrate)
YRCLM3: CC + 3% yellow root cassava leaf meal
YRCLM5: CC + 5% yellow root cassava leaf meal

Feeds and feeding system

The nutrient composition of the commercial concentrate used was as follows: crude protein 31% and crude fibre <6%. The control diet consisted of the concentrate only (Vital Feed Mill Company), while the test ingredient was mixed with maize and rice bran of the following proportions: (%, as fed): maize meal 45, rice bran 10.

Cassava leaves were collected from a farmer's demonstration farm in Amizi Olokoro in Umuahia South Local Government Area of Abia State. The clean, fresh, green cassava leaves were air-dried for two to three days and were then milled to a meal with a particle size less than 1 mm and stored in nylon bags before mixing with the control diet.

Measurements

Colour of yolk was measured by a colorimeter as described by Faquinello, *et al.,* 2004, which included three parameters: lightness or darkness of yolk (L); chromaticity coordinates (a and b), where a is redness, -a is greenness, +b is yellowness, and -b is blueness. The weights of albumen, yolk, and eggs were measured after collecting three eggs from each dietary treatment / replicate. The yolks of the quail eggs were analyzed for dry matter, crude protein, ether extract, calcium and phosphorus. Egg production and feed consumption were recorded every week from the sixth to fifteenth week of lay.

Statistical analyses

Data were analyzed by ANOVA using the General Linear Model and Turkey Test Comparisons of the Minitab Statistical Software version 12. The sources of variation were: treatments and error.

RESULTS AND DISCUSSION

The compelling need to harness the potentials of the numerous unconventional raw materials and agro-industrial by-products as part replacement for the more expensive conventional feed ingredients have been seriously expressed (Aderemi *et al.*, 2006). This need has arisen mainly from the increasing demand for and supply deficit of conventional feed resources with a concomitant sharp rise in their prices. The net effect of increased unit cost of the conventional feed resources is increased cost of the compounded rations, which by extension gives rise to increased cost of meat and animal products. It then becomes highly imperative that other sources for rapid livestock output to meet the growing human demands for animal protein foods are sourced. Such other sources should be cheap and nutritionally adequate for feeding animals with the aim of lowering the cost of producing meat.

Yolk colour

The quails fed the diets containing cassava leaf meal had yolks with lower values for lightness compared with the control (CC) (Table 1). Greenness, coming close to red, and chromatic value were higher for the yolk of eggs from the quails fed CLM5 than for the others.

Table 1. Effect of diet on yolk colour (Means and SEM)

	CC	YRCLM3	YRCLM5	SEM
Lightness "L"	$52.3^{b} \pm 0.18$	$51.3^{a} \pm 0.18$	$51.8^{ab} \pm 0.1$	0.25
Greenness "-a"	$-1.45^{b} \pm 0.13$	$-0.73^{a} \pm 0.13$	$-1.48^{b} \pm 0.13$	0.19
Yellowness "b"	$37.1^{b} \pm 0.31$	$39.7^{a} \pm 0.31$	$37.2^{b} \pm 0.31$	0.44

a, b: Means in the same row without letter in common are different at P<0.05

Yolk weight and the ratio between yolk and albumen weights

Eggs from quail fed the 5% cassava leaf meal (Table 2) had the heaviest yolks and the highest proportion of yolk. The nutrients in the 5% cassava leaf meal which was sourced from Pro-vitamin A variety was high, which also increased the pigmentation of the yolk which was converted into the nutrients of yolk by the laying quails. This explains why the quails supplied with 5% cassava leaf meal laid eggs with higher ratios between yolk and albumen and heavier yolk weight than the quails given the other diets.

Table 2. Effect of diet on yolk weight and the ratio between yolk and albumen weight

	CC	YRCLM3	YRCLM5	SEM
Albumen weight (g)	$5.62^{a}\pm0.051$	5.72a ±0.051	$5.64^{a}\pm .050$	7 .1
Yolk weight (g)	$3.35^{b}\pm0.033$	$3.36^{b}\pm0.033$	$3.48^{a}\pm0 .032$	6.2
Yolk, % of yolk+albumen	$59.9^{b}\pm0 .006$	$59.2^{b}\pm0 .006$	$62.0^{a}\pm .006$	0.8

a, b: Means in the same row without letter in common are different at P<0.05

Nutrients in the yolks

Cassava leaves have more carotene and other pigments that are incorporated into the yolk, which might explain why yolks of the quails fed 5% cassava leaf meal appeared to have the highest dry matter content (Table 4).

Table 3. Effect of dietary supplements on the nutrient composition of yolk (%)

Parameters	CC	YRCLM3	YRCLM5
DM	51.5	56.5	51.7
CP	30.9	29.0	29.3
EE	62.3	59.2	64.1
Ca	0.39	0.34	0.39
P	0.86	0.71	0.91

Egg weight and production

Eggs from quails fed 5% cassava leaf meal tended to be heavier and laying rate and feed conversion were better than on the other diets. It is probably because the rich array of nutrients in the leaf of the Pro-vitamin A Cassava was responsible for these effects.

Table 4. Effect of diet on egg weight and rate of production

Parameters	CC	YRCLM3	YRCLM5	SEM
Mean egg weight (g)	$10.6^{b}\pm 0.04$	$10.8^{ab}\pm 0.04$	$10.9^{a}\pm 0.04$	0.06
Egg production (%)	$87.8^{ab}\pm0.8$	$85.2^{b}\pm 0.8$	$89.6^{a}\pm 0.8$	1.2
Feed /egg (g /g)	$29.3^{ab}\pm 0.22$	$29.9^{b}\pm0.22$	$28.8^{a}\pm0.22$	0.3

a, b: Means in the same row without letter in common are different at P<0.05

CONCLUSION

It can be concluded based on finding of this study that supplementing rations with pro-vitamin "A" cassava leaf meal to improve japanese quail eggs yolk colour at the inclusion level of 5% of cassava leaf meal in quail diets improved yolk colour, feed conversion and mean egg and yolk weights.

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EFFECT OF SUPPLEMENTING TIGERNUT (*CYPERUS ESCULENTA VAR SATIVUS*) MEAL ON HAEMATOLOGY AND BLOOD CHEMISTRY OF FEMALE WEANER RABBITS

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ABSTRACT
This experiment was conducted to determine the effect of feeding tigernut meal on haematology and blood chemistry of female weaner rabbits at graded levels of inclusion (0%=T_1, 10%=T_2, 20%=T_3 and 30%=T_4). Twenty-four (24) clinically, healthy female weaner rabbits were used in the experiment to evaluate the effect of feeding varying levels of tigernut meal diet which was randomly divided into 4 groups of 6 animals per treatment with 2 animals per replicate given 3 replicates per treatment, in a completely randomized design. Water and feed were given ad libitum. The experiment lasted for 120 days. Simple Descriptive Statistics and Analysis of Variance were used to analyze the data while the New Duncan's Multiple Range Test was employed to compare treatment means. The blood chemistry and haematology showed no significant different ($P>0.05$) in PVC, Hb, RBC while MCV and MHC differed significantly ($p<0.05$) between WBC, neutrophil and lympocyte for T_1 to T_2, T_3, and T_4 showed no significant difference ($P>0.05$) among them. This study revealed that tigernut meal is rich in carbohydrate, it also showed that the tigernut meal could be used as a partial or total replacement for maize at upto 30% level of inclusion without any adverse effect on the blood indices of the female weaner rabbits.

INTRODUCTION
The high cost of maize as the main energy source for livestock and a staple food for Nigerians and Agro-allied companies including brewing industries cannot be over- emphasized. The resultant effect is high cost of animal protein hence inability of the populace to meet the minimum dietary protein intake of 56g per person per day as recommended by the Food and Agricultural Organization of the United Nation (Fasuyi, 2005).
Many attempts have been made to solve this problem through the use of some non-conventional energy sources in livestock such as maize offal (Vantsawa *et al.*, 2008), cassava (Udedibie *et al*., 2009). These tuber crops have been found to be of good potential but with limited crude protein content which is often below 3%.
Tiger nut is a tuber rich in energy content (starch, fat, sugar), minerals (mainly phosphorus and potassium), and vitamins E and C thus, making the tuber also suitable for diabetic patients to take (Ekeanyanwu and Ononogbu, 2010). Tiger nut tubers contain almost twice the quantity of starch as potato or sweet potato tubers. The oil of the tuber was found to contain 18.0% saturated (palmitic acid and stearic acid) and 82.0% unsaturated (oleic acid and linoleic acid) fatty acids (Ezeh *et al*., 2014). The moderately high content of phytosterols further enriches the quality and value of tiger nut oil as a food source, according to Consejo Regulador de Chufa de Valencia (Regulating Council for Valencia's Tigernuts, 2002).There is paucity of information on its potential as rabbit feedstuff in Nigeria, this study is therefore designed to evaluate its suitability as replacement for maize in rabbit production and the increase rearing of rabbit will improve and complement the quantity and quality of meat supply in the country.

MATERIALS AND METHODS
The experiments were carried out at the Rabbitary Unit of the Teaching and Research Farm of Abia State University, Umuahia Location. The Campus is located within the Southeastern Nigeria and lies between Longitude 07º 33' E and Latitude 05º 29' N at about 8km East of the Umuahia-Ikot Ekpene road. It is 140 km North of Port Harcourt International Airport, 135 km South of Enugu Airport and 80 km East of Owerri Airport. The experiment lasted for 120 days. The tiger nut seeds were purchased from "Ama Hausa" in Umuahia in Abia State, Nigeria. The milling was done at Feed Mill Unit of National Root Crops Research Institute, Umudike. Twenty-four female weaner rabbits were used for the experiment and were assigned to the four treatment diets following Completely Randomized Design,

where each treatment had six rabbits which was further replicated 3 times with 2 rabbits per replicate and the breed used for the studies was New Zealand White with an average weight of 980g and 6-8 weeks of age. The rabbits were purchased from the rabbit unit of National Root Crops Research Institute, Umudike.

RESULTS AND DISCUSSION

Effect of tigernut meal on blood chemistry and haematology of rabbits

Effect of levels of inclusion of tigernut meal on haematology is presented in Table 1. The result showed no significant ($P>0.05$) effect on packed cell volume (PCV), haemoglobin (HB) and Red blood cell (RBC). In mean corpuscular volume (MCV), there were no significant differences ($P>0.05$) among T_2 (10%), T_3 (20%) and T_4 (30%) but they differed significantly ($P<0.05$) from T_1 (0%). The PCV, HB and RBC values obtained in this study are similar to the values reported by Mohammed *et al.* (2005) who fed similar diets to growing rabbits. In Mean Corpuscular Haemoglobin (MCH) of rabbits that consumed diets containing 10%, 20% and 30% of tigernut meal. The parameters (MCV and MCH) had similar trend indicating lack of abnormality. The values are close to the normal range of 60 – 73 fl and 16.23pg for MCV and MCH respectively (Chmurska-Gasowska M, *et al;* 2021). No sign of ill-health or abnormal values were reported during the period of the experiment. Abnormal values may be an indication of anaemia (Abu *et al.*,1999). It also means that it is not toxic to feed rabbits with diets containing 30% tigernut meal.

The effect of levels of inclusion of tigernut meal on white blood count is presented in Table 2.

In white blood cells, there were no significant differences ($P>0.05$) among T_2 (10%), T_3 (20%) and T_4 (30%) but they differed significantly ($P<0.05$) from T_1 (0%) and it was the same in the case for neutrophil. In lymphocyte, T_1 differed significantly ($P<0.05$) from T_2, T_3 and T_4 but there were no significant differences ($P>0.05$) between T_3 and T_4. The values are similar and fall within the normal range for health rabbits as reported by Ahamefule *et al*. (2006). In basophil and eosinophils there were no result.

The white blood cell counts (%) of monocytes, lymphocytes, basophils, neutrophils and eosinophils were also not significantly different ($P>0.05$). The values are similar and fall within the normal range for healthy rabbits as reported by Ahamefule *et al*., (2006).

The effect of levels of inclusion of tigernut meal on serum biochemistry is presented in Table 3. The albumin values showed no significant differences ($P>0.05$) among the treatments and the values fell within the normal range of 2.5 to 4.0 g/dl reported by Chmurska-Gasowska M, *et al;* (2021) The globulin values (1.02 to 2.02 g/dl) showed significant differences ($P<0.05$) among treatments. The values for T_1, T_2, $T_3$and T_4 were lower than the values reported by Chmurska-Gasowska M, *et al;* (2021) but similar to 1.94-2.26 g/dl obtained by Ani, A.O and Ugwuowo, L. C(2011) who fed various tropical energy feed resources to growing rabbits. The total serum protein values (4.42 to 5.53 g/dl) were within the range reported by Chmurska-Gasowska M, *et al;* (2021) but lower than 5.81-6.75 g/dl reported by Ani, A.O and Ugwuowo, L. C(2011) . Since total serum proteins, albumin and globulin are generally influenced by total protein intake Ani, A.O and Ugwuowo, L. C(2011) the values obtained in this study seemingly indicated nutritional adequacy of the dietary proteins. Abnormal serum albumin usually indicates an alteration of normal systemic protein utilization (Apata, 1990). Awosanya *et al.* (1999) demonstrated the dependence of blood protein on the quality and quantity of dietary protein.

Glucose level was significantly different ($P<0.05$) among treatments, the blood glucose was within the range 4.2-8.9mmol/1 reported by Fudge (1999). Since glucose level was within the normal range, possibilities of anorexia, diabetes, liver dysfunction and mal-absorption of fat, which are the symptoms of abnormal glucose level in the blood (Bush, 1991) is ruled out. The blood urea values were within the range of 2.50 to 5.80 mmol/l reported by Njidda and Hambagda (2006), who fed sesame seed meal to growing rabbits in tropical environment. Decreased blood urea may be associated with severe liver disease or protein malnutrition (Bush, 1991). There was no sign of ill-health observed in the rabbits and from the result of the feed analysis all the diets met the minimum levels required in the diets of growing rabbits. Serum creatinine levels were within normal range and did not differ ($P>0.05$) among treatment groups. The values obtained for animals on diets T_1, T_2 and T_3 were in consonance with the findings of Ahamefule *et al.*, (2009), who fed cassava peels processed using different methods. The results also suggest that there was no wasting or catabolism of muscle tissues, and that animals were not surviving at the expense of body reserve. This was a good indication that dietary protein was well utilized by the rabbits.

CONCLUSION

The result of this study indicated that the tigernut inclusion up to 30% may not have adverse effects on haematology and serum biochemical indices on the female weaner rabbits

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Table 1: Effect of levels of inclusion of tigernut meal on haematology of female Rabbits

	Treatments of dietary levels of tigernut meal (%)				
Parameters	**T_1(0%)**	**T_2(10%)**	**T_3(20%)**	**T_4(30%)**	**SEM**
Packed cell volume (%)	36.67	37.52	35.45	38.54	0.65^{ns}
Haemoglobin (g/dl)	11.34	12.15	13.00	11.05	0.44^{ns}
Red blood cell ($x10^6/mm^3$)	4.35	4.50	4.51	4.53	0.44^{ns}
MCV (fl)	67.30^a	53.12^b	55.60^b	56.40^b	3.14
MCH (pg)	22.20^a	18.50^b	18.70^b	19.00^b	0.87

a, b, c: Means with different superscript on the same row differ significantly (P<0.05).
n.s= Not significantly different
SEM= Standard error of mean.

Table 2: Effect of feeding tigernut on white blood count of female rabbits

	Treatments of dietary levels of tigernut meal (%)				
Parameters	**T_1 (0%)**	**T_2 (10%)**	**T_3 (20%)**	**T_4 (30%)**	**SEM**
WBC ($\times10^3$/ui)	11.74^a	8.12^b	8.13^b	8.10^b	0.91
Neutrophil (%)	53.00^a	37.15^b	36.00^b	34.13^b	4.35
Lymphocyte (%)	62.44^a	48.24^b	43.34^c	41.35^c	4.76
Basophil (%)	0.00	0.00	0.00	0.00	0.00
Eosinophils (%)	0.00	0.00	0.00	0.00	0.00

a, b, c: Means within each row and with different superscripts are significantly (P<0.05) different.

Table 3: Effect of feeding tigernut on serum biochemistry of female rabbits

	Treatments of dietary levels of tigernut meal (%)				
Parameters	**T_1 (0%)**	**T_2 (10%)**	**T_3 (20%)**	**T_4 (30%)**	**SEM**
Total Serum Protein (g/dl)	4.52	4.42	5.53	5.01	1.19^{NS}
Albumin (g/dl)	2.81	3.01	3.51	3.39	0.94^{NS}
Globulin (g/dl)	1.71^{a}	1.41^{b}	2.02^{a}	1.62^{a}	0.02 *
Glucose (mg/dl)	6.50^{a}	4.80^{b}	6.40^{a}	7.60^{b}	1.32 *
Urea (g/dl)	3.10^{a}	2.90^{b}	2.60^{b}	3.00^{a}	0.71*
Creatinine (ms/dl)	63.10^{a}	67.11^{a}	54.11^{b}	52.10^{b}	4.65*

Mean within the same row with different superscripts significantly different (P<0.05); NS=Non significant (P>0.05); *=significant (P>0.05); SEM= Standard Error of Means.

CHEMICAL COMPOSITION AND EGG LAYING PERFORMANCE OF INDIGENOUS LAYERS FED DIETS CONTAINING MONDAI WHITEI

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ABSTRACT
Historically, adding herbs and spices to animal feed has helped manage diseases. However, due to the usage of synthetic antimicrobial growth promoters (AGP), they have been ignored. The plant Mondai whitei is useful for treating diseases. This research was conducted using a total of 105 indigenous layers comprising seventy-five females and thirty males to determine their responses to inclusion of Mondai whitei at five varying dietary levels (0mg/kg, 500mg/kg, 1000mg/kg, 1500mg/kg and 2000mg/kg). The birds were randomly assigned to five dietary treatments with each treatment comprising 3 replicates of 7 birds each. The experiment was laid out in a Completely Randomized Design. Data collected include; growth performance, Internal and external egg qualities as well egg lipid profile in three phases (I, II and III). The results showed that age at maturity, egg weight, and average body weight all varied significantly (p>0.05) at phase I, there were no variations in feed intake, hen day egg production, FCR, weight gain, daily weight gain, eggs per dozen that were statistically significant (p0.05). Packed cell volume recorded highest (31.00% and 28%) at inclusion levels of 500mg/kg and 1000mg/kg at phase II the packed cell volume recorded highest (30.00% and 35.67%) at the inclusion levels of 1000mg/kg and 2000mg/kg and red blood cell was highest (6.40g/dl) at the inclusion levels of 2000mg/kg at phase I while in phase II, total protein was highest (6.80g/dl) and at phase III it was highest (7.50g/dl) at control levels (0mg/kg) and lowest (551.87mg/dl) at inclusion levels of 1000mg/kg at phase I and phase II recorded higher (653.95 mg/kg) at inclusion levels of (0mg/kg) and lower (574.63 mg/dl) at 1500mg/kg inclusion levels. This study concluded that inclusion level of Mondai whitei up to 2000g improved the weight gain and egg laying performance.

Keywords: *Mondai whitei, Herbs, antimicrobial.*

INTRODUCTION
Due to the rising population, there is a greater need for protein, which can be produced efficiently and in large quantities through animal production. Nigeria has the largest population in Africa with a population of over 200 million. The severe lack of animal protein in the diet of the average Nigerian calls for a logical response, such as raising livestock output to meet animal protein needs. It is impossible to overstate the value of poultry to the national economy given that it has grown to be a popular business for small-scale farmers who make considerable economic contributions to the national GDP. According to Aboki *et al.* (2013), poultry production has a significant impact on increasing employment prospects and animal food production in Nigeria. In the rural parts of tropical and sub-tropical countries, indigenous chickens are commonly available and are retained by the bulk of the rural population. Native African chickens are often hardy, able to thrive in rural settings, require little to no care, and can adapt to changes in feed availability.

In the last ten years, there had been strong opposition to the use of antibiotics as growth promoters. It is reasonable to be concerned about the negative effects that could arise from their application, such as the emergence of resistant microorganisms and possible negative impacts on human health (Rahmatnejad *et al.*, 2009). Breeders have been led by this to look for alternative substances that remove unfavourable reactions in chicken and a potential risk to human health. To enhance the performance and immune response of chicken, probiotics, prebiotics, and medicinal herbs have been employed as natural additions in poultry feeding (Peric *et al.*, 2010). Every day, more medicinal plants become available as possible sources of herbal feed additives for laying hens (Suriya *et al.*, 2012). This study examines the chemical composition and egg laying performance of native layers fed diets containing *Mondai whites*.

METHODOLOGY

Study Area

This study was conducted at the Poultry Unit of the Teaching and Research Farms, Federal University of Agriculture Abeokuta, Ogun State, Nigeria's. The study area lies in South-Western Nigeria's. The area has minimum and maximum temperatures of 20.66^{0}C and 35.48^{0}C, respectively. It is located around latitude 7013'49.46"N and longitude 3026'11.98"E, 76 meters above sea level. It experiences 1037mm of precipitation on average per year (Google Earth, 2015).

RESULT AND DISCUSSION

Proximate composition of test ingredient (%)

The Proximate composition of the test ingredients is presented in Table 1. *Mondai whitei* has dry matter content of 95.6%, Crude protein of 12.38%, ether extract of 5.00%, ash of 6.00%, Crude fibre of 17.50% and NFE of 59.12%. The mineral composition of the test ingredients has magnesium 9.34, potassium 10.31, calcium 9.12, phosphorus 6.85, sodium 5.61, iron 0.20 and manganese (0.74). The quantitative assay of phytochemical contents of *Mondai whitei* has tannin 0.840, flavonoid 0.872, steroid 0.362, saponin 1.043 and alkaloid, 0.451.

Table I: Percentage chemical composition of *Mondai whitei*

Proximate (%)	Quantity	Minerals(mg/g)	Quantity	Phytochemicals	Quantity
Dry matter	95.23	Magnesium	9.34	Tannin	0.840
Ether extract	5.00	Potassium	10.31	Steroid	0.362
Crude protein	12.38	Calcium	9.12	Saponin	1.043
Crude fibre	17.50	Phosphorus	6.85	Flavonoid	0.872
Ash	6.00	Sodium	5.61	Alkaloid	0.451
NFE	59.12	Iron	0.20		

NFE= Nitrogen free extract

The result of *Mondai whitei* on body weight, age at maturity and first egg weight is presented in Table 2. *Mondai whitei* had no significant (p>0.05) effect on the age at maturity, body weight and egg weight of the birds. Birds on inclusion levels of 500mg/kg and 1000mg/kg recorded higher (182.33 and 182.00, respectively) age at maturity while average body weight was highest (950 g) at inclusion levels of 1500mg/kg and also egg weight was highest (38.03) at inclusion levels of 2000mg/kg.

Table II: Effect of *Mondai whitei* on body weight, age at maturity and first egg weight

Inclusion (mg/kg) Levels **Parameters/level of inclusion**	0	500	1000	1500	2000	SEM	P-Value
Age at maturity (days)	179.69	182.33	182.00	179.00	178.00	0.87	1.39
Egg weight (g)	33.50	37.18	30.31	34.54	38.03	0.003	0.83
Average body weight (g)	936.7	913.3	913.3	950.0	906.7	0.81	1.20

SEM= Standard error of mean

The result of the effects of *Mondai whitei* on the laying performance of indigenous layers is presented in Table 3. At 0 – 5 weeks of lay, the effects of *Mondai whitei* on total feed intake, hen day production, daily weight gain and eggs per dozen was not significant (p<0.05). Birds fed at inclusion levels of 500mg/kg had significantly (p>0.05) higher daily weight gain while birds on inclusion levels of 1000mg/kg and 1500 mg/kg recorded higher (89.33g and 89.00g) total feed intake while inclusion levels of 2000 mg/kg recorded the lowest. Egg per dozen recorded higher (0.61) at inclusion levels of 1500 mg/kg follow by 2000 mg/kg and lower in 500 mg/kg. Weight gain recorded highest (180g) at inclusion levels of 500 mg/kg while it is lower (140g) at inclusion levels of 0 mg/kg. Hen day production recorded lowest (11.63) percentage at 500 mg/kg but slightly higher 25.97% and 24.53% at inclusion levels of 1500 mg/kg and 2000mg/kg and no mortality recorded across the treatment.In phase II, the result shows that there is no significant (p>0.05) differences across the treatments. Total feed intake was highest (123.67g and 122.03g) at inclusion levels of 500mg/kg and 1500 mg/kg and daily weight gain was high (3.42g) at inclusion levels 1000mg/kg. In phase III, weight gain and daily weight gain were significant (p<0.05). There was no significant (p>0.05) differences in hen day production, FCR, egg per dozen and as well as mortality.

Table III: Effect of *Mondai whitei* on the performance of indigenous layers

Inclusion (mg/kg) levels							
Parameters/level of inclusion	0 mg/kg	500	1000	1500	2000	SEM	Pval
Phase I (0-5 weeks)							
Total feed intake(g/bird)	88.67	87.33	89.33	89.00	83.00	1.10	0.25
Hen day production (%)	18.53	11.63	14.00	25.97	24.53	2.32	0.20
FCR {feed(g)/dozen eggs}	238.72	345.37	277.26	164.17	163.82	25.38	0.38
Weight gain (g)	140.00	180.00	166.67	163.33	156.67	5.06	0.13
Daily weight gain (g)	4.00	5.14	4.76	4.67	4.48	0.14	0.13
Eggs per dozen	0.43	0.27	0.33	0.61	0.57	0.05	0.20
Mortality	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Phase II (5-10 weeks)							
Total feed intake(g/bird)	119.60	123.67	121.77	122.03	120.40	0.73	0.49
Hen day production (%)	34.87	35.00	28.57	39.17	34.83	1.68	0.44
FCR {feed(g)/dozen eggs}	119.35	132.28	157.19	115.84	133.28	7.65	0.51
Weight gain (g)	90.00	56.67	120.00	86.67	53.33	8.83	0.07
Daily weight gain (g)	2.50	1.62	3.42	2.48	1.52	0.25	0.08
Eggs per dozen	1.01	0.94	0.83	1.06	0.96	0.05	0.70
Mortality (%)	0.33	0.07	0.00	0.00	0.13	0.001	0.08
Phase III (10-15 weeks)							
Total feed intake(g/bird)	119.23 ^{b}	123.10 ^{a}	121.63^{ab}	119.90 ^{b}	121.00^{ab}	0.48	0.05
Hen day production (%)	21.63	16.00	17.53	16.37	21.57	1.25	0.45
FCR {feed(g)/dozen eggs}	224.29	291.54	239.45	285.71	202.99	18.33	0.52
Weight gain (g)	50.67 ^{b}	56.67 ^{b}	60.00 ^{b}	116.67 ^{a}	73.33 ^{a}	7.58	0.01
Daily weight gain (g)	1.79 ^{b}	1.62 ^{b}	1.71 ^{b}	3.33 ^{a}	2.09 ^{b}	0.21	0.02
Eggs per dozen	0.61	0.44	0.51	0.45	0.63	0.04	0.51
Mortality	0.00	0.00	0.00	0.00	0.00	0.00	0.00

^{a,b} Means with the same superscripts along the rows are not significantly different
SEM= Standard error of mean

CONCLUSION AND RECOMMENDATION

In conclusion and feeding of birds with diets containing *Mondai whitei* improved the intake of feed at inclusion levels of 1000 mg/kg and 1500 mg/kg. Inclusion of *Mondai whitei* at 500mg/kg, 1000mg/kg, 1500mg/kg and 2000mg/kg improve the weight gain. Hen day production was influenced at inclusion levels of 1500 mg/kg and 2000 mg/kg respectively in phase I, and in phase II at inclusion levels of 500 mg/kg and 1500 mg/kg. The recommendation suggested that dietary supplementation of *Mondai whitei* at inclusion level of 500mg/kg, 1000mg/kg, and 1500mg/kg. At inclusion levels of 1000 mg/kg and 1500 mg/kg, feeding birds meals containing *Mondai whitei* enhanced feed intake. The weight gain is improved by adding *Mondai whitei* at doses of 500 mg/kg, 1000 mg/kg, 1500 mg/kg, and 2000 mg/kg. In phase I, inclusion levels of 1500 mg/kg and 2000 mg/kg, and 500 mg/kg and 1500 mg/kg, respectively, had an impact on hen day production.

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EFFECT OF POULTRY MANURE RATE AND NPK 15:15:15 ON PERFORMANCE AND NUTRITIONAL CONTENT OF SWEET POTATO (*IPOMOEA BATATAS* L.)

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ABSTRACT

A field experiment was carried out to determine the effect of different rate of Poultry manure (PM) and NPK 15:15:15 on vine length, number of leaves, plant height, number and weight of harvested tubers with the Proximate contents of sweet potato. The experiment was laid out in a Randomized Complete Block Design (RCBD) with five treatments replicated three times. The treatments were 0 kg/ha of poultry manure (PM) (no treatment), 15 kg N/ha PM, 30 kg N/ ha PM, 45 kg N/ha PM and NPK 15:15:15.. The result showed that, application of PM at 45 and 30 kg N /ha had a positive response significantly on vine length than other treatments. Nitrogen sources also favoured production of leaves and number of tubers but 45 kg N/ha of PM produced tubers with more weight comparable to 30kg N/ha than other rates and sources. Treatment with NPK 15:15:15 gave high value of ash content, crude protein, crude fat and crude fibre which also increases with increase in the rate of PM application. However, increase in N rate or source decreased carbohydrate and moisture content of the crop. Application of PM at the rate of 30 kg N /ha is therefore recommended for best growth yield of and DM of sweet potato since it also increased the quality in terms of crude protein

Keywords: *Poultry manure, proximate, tubers, quality, sweet potato*

INTRODUCTION

Sweet potato (Ipomea batatas) is one of the major food crops in the world, and it rank second to yam in Nigeria as a major important tuber crop, contributing to the people food requirement (Karam *et al*., 2009). The crop is particularly important crop for subsistence farmers in Africa and other developing countries. Sweet potato is a very important food security crop due to its relatively short growing period, tolerance to drought and high yield from poor soils. It is used as a famine reserve for many of these households (Ofor, 2011).

Sweet potatoes possess many positive health benefits including sources of anthocyanins, phenolic compounds and other bioactive compounds (Alum *et al.,* 2013). The vegetable crop also possesses antioxidant activities. Sweet potatoes is highly rich in nutrient elements. A 100g edible portion of sweet potatoes yield 360kj energy, 20.1g carbohydrate, 3.0g dietary fibre, 0.1g fat, 1.6g protein, 30.0mg calcium, 0.6mg iron, 25.0mg magnesium, potassium 337mg, thiamine 0.1mg, riboflavin 0.1mg, phosphorus 47.0mg, sodium 55mg, zinc 0.3mg, folate 11Ng, pantothenic Acid 0.8mg, Niacin (B3) 0.61mg, 79.8% Water, about 2.4mg vitamin C is reported in sweet potato and 0.25mg Vitamin B6. In spite of these, the nutrient compositions as documented by several authors have been revealed to vary from cultivar to cultivar (Eleazu and Ironua 2014). In another study, it was discovered that root and vine proximate compositions were shown to vary with sweet potato cultivars (Gebreegziabher *et al.*, 2014).

The tuber also contains significant amount of vitamins A, B1, B2 and C and minerals such as K, Na, P and Ca. The young leaves are also rich in protein, minerals and vitamins (Onwueme and Sinha., 2011). The crop is efficient in the production of carbohydrates, proteins, vitamins and cash income per unit area of land and time also, the yellow-and orange-fleshed varieties of sweet potatoes are high in beta-carotene, which can be converted into vitamin A in the intestines and liver. It has been shown that even small amounts of these sweet potatoes as a regular part of the diet will eliminate vitamin A deficiency in adults and children. (Magagula *et al*., 2010).

Poultry manure (PM) contains all 13 of the essential plant nutrients that are used by plants. Using poultry manure as a fertilizer for crops or trees may provide a portion, or all, of the plant requirements. The amount of nutrients provided depends on the nutrient content of the manure (lb of nutrient / ton of manure) and the amount of manure applied (ton of manure / acre) (Zublena *et al*., 2006). Because of the high nutritional and economic value, it is necessary to improve yield and its related traits that can be achieve through balance availability of all the nutrients in the crop. This work is therefore targeted to examine the effect of different rate of poultry manure application on the yield and nutritional composition of sweet potato.

MATERIALS AND METHODS

The experiment was conducted behind the Horticultural Unit Experimental Site of the Federal College of Agriculture, Moor Plantation, Ibadan, Nigeria. Soil and poultry manure samples were collected prior to the commencement of the experiment at random from the site at a depth of 0.15 cm using soil auger soil samples collected were air dried and sieved through 2mm sieve for both physical and chemical analysis. The poultry manure used for the experiment was air dried and taken to the laboratory for analysis before incorporated into the soil.

The experimental plot size of 19 m x 11 m (209 m^2) was laid out in a Randomized Complete Block Design (RCBD) with five treatments replicated three times. The size of each replicate was 19 m x 3 m. each replicate was divided into five plots measuring 3 m x 3 m. the replicates were separated by 1 m alley in between while the plots were separated by 0.5 m. The treatments were 0 kg/ha (no treatment), 15 kg N/ha poultry manure, (PM), 30 kg N/ ha poultry manure, 45 kg N/ha poultry manure and NPK 15:15:15.

The land was cleared mechanically with the use of tractor, stumping was done manually using hoe and Cutlass, packed of debris and tilled. Heaps were made at a spacing of 1 m 1 m, the treatment poultry manure at specified rates were applied before planting (2 weeks before planting and was heavily watered for quick mineralization) Potato vine cuttings were obtained from a commercial farm in Ibadan. The variety used was Kenspot 4 (orange flesh with cream colour). The cuttings were planted at a space of 1 m by 1 m. NPK 15:15:15 was applied two weeks after planting. Weeding was done manually by hoeing before the establishment of the crop.

Data collection commenced 4 weeks after planting (WAP) and continued until eight weeks. Four plants were tagged on each plot for data collection Growth and yield parameters measured were; Vine length, Number of leaves, Number of tubers per plot and weight of tubers per plot which was converted to kilogram per hectare. .

Vine length of each sample plant was measured using a calibrated ruler. The number of fully expanded leaves of each tagged plant physically counted. The tuber of sweet potato harvested on each plot was weighed using the weighing scale in kilogram.

Harvesting was carefully done twelve (12) weeks after planting, by careful uprooting of the tubers with cutlass and hand. After harvesting, yield parameters were taken by weighing the harvested tubers and taken the samples to the laboratory for proximate analysis after air drying the sliced samples.

Data collected was subjected to Analysis of Variance (ANOVA) to test for significance of treatment on the crop and the significant means were separated using Least Significant Difference (LSD) $p<0.05$.

RESULTS

The result of the physical and chemical properties of the soil used for the experiment is presented in Table 1. It shows that the soil was slightly acidic with a pH of 6.8. Total nitrogen was at normal range (1.05 $mgkg^{-1}$) which falls within the normal standard value of 1-1.5, available phosphorus 12 $mgkg^{-1}$ compared to the standard value of 7-20 was high and organic carbon 1.42 $mgkg^{-1}$ compared to the standard value of 1.0 -1.4 was slightly high (FFD, 2021), Exchangeable base: potassium, calcium, magnesium and sodium were 0.30, 1.53, 0.41 and 0.31(cmol/kg) respectively. The textural class of the soil was sandy soil with sand (914 g/kg), silt (56 g/kg) and clay (30 g/kg). The result of the analysis of the Poultry manure used for the experiment is shown in table 1 and it revealed that the Nitrogen content is 18 %, Phosphorus is 24 % and Potassium is 0.90 %.

Table 1: Pre-planning soil and Poultry manure chemical properties and particle size distribution

Parameters	Units	Values
Ph		6.8
Organic carbon	gkg^{-1}	1.42
Total Nitrogen	gkg^{-1}	1.05
Available Phosphorus	$mgkg^{-1}$	12
Exchangeable bases	cmol/kg	

Ca^{2+}		1.53
Mg^{2+}		0.41
K^{+}		0.30
Na^{+}		0.31
Exchangeable acidity	cmol/kg	3.91
Particle Size Distribution	g/kg	
Sand		914
Silt		56
Clay		30
Textural class		Sandy soil

Chemical properties of Poultry manure

Parameters	Values (%)
Total nitrogen	18
Total Phosphorus	24
Total Potassium	0.90

The effect of different rates of poultry manure on vine length of sweet potato was presented in Table 2.
At 4WAP, with 30kg N/ha poultry manure, the vine length (25.00cm) was significantly longer than control (16.01cm), 30kg N/ha poultry manure (16.95cm) and NPK 15:15:15 (15.83cm) but not significantly different from 45 kg N/ha poultry manure (23.50cm). At 6 WAP, 30kg N/ha poultry manure produced vine length 33.75cm which was significantly longer that control (20.50cm), 15kg N/ha poultry manure (20.67cm) and NPK 15:15:15 (22.42cm) but not significantly different from that of 45 kg N/ha poultry manure (30.42cm).
At 8 WAP the vine length of 45 kg N/ha poultry manure (48.58cm) and 15kg N/ha poultry manure (45.33cm) were significantly longer than control (31.42cm), 15kg N/ha poultry manure (30.33cm) and NPK 15:15:15 (33.08cm).
Effect of different rates of poultry manure on number of leaves of sweet potato was presented in Table 2. At 4WAP the number of leaves produced by 15kg N /ha poultry manure (11.33), 30kg N/ha poultry manure (11.50) and 45 kg N/ha poultry manure (11.83) were not significantly different from each other but were significantly higher than control (9.58) and NPK 15:15:15 (10.17) although control and NPK 15:15:15 were significantly different from each other. At 6 WAP 30kg N/ha poultry manure produced leaves which were significantly higher (19.17) than control (11.33), 15kg N/ha poultry manure (13.00), 45 kg N /ha (15.33) and NPK 15:15:15 (12.00) although control, 15kg N/ha poultry manure and NPK 15:15:15 were not significantly different from each other (Table 2). At 8 WAP, the leaves of 45kg N/ha poultry manure (31.50) was significantly higher in number than control (19.33), 15kg N/ha poultry manure (23.83), 30kg N/ha poultry manure (28.17) and NPK 15:15:15 (23.50) however, leaves of 15 kg N/ha and NPK 15:15:15 were not significantly different from each other.
The result of effects of different rates of poultry manure on number of tubers and tuber weight of sweet potato was presented in Table 2. The result revealed that, sweet potato responds positively to nitrogen fertilization from all the sources and rates also, sweet potato that received poultry manure of 30 kg N/ha produced tubers which were statistically similar in weight (281.33) with those that received 45 kg N/ha (271.00), but were significantly lower than other treatments.

Table 2: Effect of poultry manure rates and NPK 15:15:15 on vine length, number of leaves, number of tubers and tuber weight of sweet potato

Treatment	4 WAP	6 WAP	8 WAP
0 kg/ha (control)	16.01bc	20.50c	31.42b
15kg N/ha poultry manure	16.95bc	20.67c	30.33b
30kg N/ha poultry manure	25.00a	33.75a	45.33a
45kg N/ha poultry manure	23.50ab	30.42ab	48.58a
NPK 15:15:15	15.83c	22.42bc	33.08b
LSD (P=0.05)	7.53	8.48	7.71

Number of leaves

0 kg/ha (control)	9.58b	11.33c	19.33c
15kg/ha poultry manure	11.33a	13.00bc	23.83bc
30kg/ha poultry manure	11.50a	19.17a	28.17ab
45kg/ha poultry manure	11.83a	15.33b	31.50a
NPK 15:15:15	10.17ab	12.00c	23.50bc
LSD P0.05	1.68	3.23	5.03

Treatment	No of Tubers	Tuber weight (kg/ha)
0 kg/ha (control)	6.66b	95.77c
15kg/ha poultry manure	9.67ab	281.33b
30kg/ha poultry manure	11.33a	408.33a
45kg/ha poultry manure	10.67a	410.00a
NPK 15:15:15	9.67ab	271.00b
LSD(P=0.05)	3.67	71.11

Significant means were separated by LSD P<0.05

The result of nutritional composition of sweet potato is presented in Table 3. It was observed that sweet potato treated with NPK 15:15:15 had the highest value of ash content (2.30%) which was significantly higher than other treatments. This could be because, NPK 15:15:15 has the major macro nutrient to make adequate ash content available in the crop. Also, sweet potato treated with NPK 15:15:15 had the highest value of crude protein (8.60%) which was significantly higher than other treatments while the control had the least value of crude protein (1.90%).

Furthermore the highest moisture content (25.00%) was observed in sweet potato treated with control and was significantly higher than other treatments, while the least moisture content (21.00%) was observed in sweet potato treated with 30kg/ha poultry manure. Also the highest crude fibre (7.20%) and crude fat (3.15%) were observed in sweet potato treated with NPK 15:15:15 and were significantly higher than other treatment and the least crude fibre (2.09%) and crude fat (1.05%) were observed in control treatment. The result indicates that nitrogen in NPK 15:15:15 is enough for the crude fibre needed from sweet potato. However, application of PM at the rate of 45 kg N /ha can also provide reasonable amount of crude fibre from sweet potato (6.10).

Table 3: Proximate analysis of sweet potato

Treatment	Ash	Crude protein	Moisture content	Crude Fibre	DM	Crude fat	Carbohydrate
0 kg/ha (control)	1.03e	1.90e	25.00a	2.09e	68.93c	1.05c	69.93a
15kg/ha poultry manure	2.15c	3.50d	24.00b	4.15d	76.00d	2.60c	63.60c
30kg/ha poultry manure	2.10d	4.95c	21.00e	5.05c	79.00a	2.45d	64.45b
45kg/ha poultry manure	2.25b	7.70b	23.00c	6.10b	77.00c	2.80b	58.15d
NPK 15:15:15	2.30a	8.60a	22.00d	7.20a	78.00b	3.15a	56.75e
LSD(P=0.05	0.34	0	0	0	0.27	0.48	0

Significant means were separated by LSD P<0.05

DISCUSSION

The result of this experiment indicates that Nitrogen is needed for vegetative growth of crops and it buttresses the work of Zelalem *et al.*, 2009) who opined that Nitrogen in poultry manure is essential for increasing vine length plant height, leaf area index, shoot dry matter and tuber yield. This result shows the importance of Nitrogen for growth of crops and also that potato is highly responsive to N-fertilization and that N is usually the most limiting essential nutrient for potatoes growth and development (Mohammed *et al.*, 1998).

The result revealed that, sweet potato responds positively to nitrogen fertilization from all the sources and rates also, sweet potato that received poultry manure of 30 kg N/ha produced tubers which were statistically similar in weight (281.33) with those that received 45 kg N/ha (271.00), but were significantly lower than other treatments. This result corroborates the work of (Izunobi 2002) who reported that poultry manure, especially those provided from deep litter or battery cage house are the richest known farm yard manure supplying greater amounts of absorbable plant nutrient for optimum tuber growth and yield of crops.

Sweet potato is a tuber crop which although needs nitrogen but application of excess nitrogen affects the quality of the tubers. This also corroborates the work of Ahmad Ahmed *et al*., 2009) who also observed decline in some quality parameters of potato with increase in nitrogen rate. This could be the reason why the nitrogen in NPK 15:15:15 is sufficient for the crude protein in the crop.

The moisture content of any food is an indication of its water activity in the food and it is used to determine how stable and how susceptible the food is to microbial contamination (Howarth *et al*., 2001). The high moisture content recorded at zero application of PM implies that with increase in PM, concentration of other nutrients in the crop will decrease when dehydration occurs. This result corroborates the work of Idowu *et al*., 2023) who reported increase in the moisture content of eggplant, with increase application of PM. Fat is known to help the body to achieve satisfaction after eating and helps the body to absorb vitamin A, D and E (Agbenafle and Bart- Plange, 2015) and (Vishruta, 2014). The results shows that treatment with NPK 15:15:15 gave high value for crude fat significantly and that, increase in application of PM was decreasing the crude fat in the crop. .This could be because, sweet potato being a carbohydrate food, the normal N in NPK 15:15:15 is enough for the crop. (Idowu *et a*l 2023) also observed that increase in PM leads to decrease in the crude fat in egg plant.

Sweet potato treated with 30kg/ha poultry manure had the highest value off dry matter (79.00%) and was significantly higher than the other treatments. Furthermore, sweet potato treated with control had the highest value of carbohydrate content (69.93%) which was significantly higher than other treatments. (Idowu *et al*., 2023) also observed that control experiment gave the highest value for carbohydrate when different rate of PM was applied to the soil for planting eggplant.

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MINERAL COMPOSITION OF FORMULATED SWEETPOTATO WEANING FOOD

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ABSTRACT
Inadequate and poor weaning practices in addition to malnutrition remains' a serious public health challenge among the under-fives in developing countries, Nigeria included; since commercial weaning foods are not affordable and, to some extent, not available to the common man. Three weaning food samples (A, B, and C) were formulated from sweet potato, soybeans, groundnut, crayfish, and fish meal at the respective ratios of (70:10:5:15) for sample A, (60:20:5:10:5) for sample B, and (50:30:5:15) for sample C of varying quantities to make up 100g. Nutrend was used as a control (D) for commercial weaning food, and mineral composition was determined using the standard method. The mineral analysis of formulated sweet potato weaning food ranged from sodium (67.27 to 67.84mg/100g), potassium (39.17 to 45.29mg/100g), magnesium (66.44 to 67.37mg/100g), Phosphorus (425.04 to 446.22mg/100g) and calcium (8.38 to 9.05mg/100g) respectively. The mineral contents were significantly higher than the control sample except for calcium content, which had the lowest value.

Keywords: *Mineral composition, weaning food, sweet potato, formulated, malnutrition.*

INTRODUCTION
Weaning is a period of transition for the infant during which its diet changes in terms of consistency; therefore, the child is gradually introduced to semi-solid food (Garcia *et al.*, 2013). Weaning foods are foods and liquids given to infants other than breast milk or infant formulas for both nutritional and developmental reasons to enable the transition from milk feeding to family foods (Abeshu *et al*., 2016).

In developing countries, 70% of weaning foods are supplied by cereals, which are relatively poor sources of protein (Aduni *et al*., 2016). Apart from protein and energy, which infants need in their diet, magnesium, phosphorus, and microelements can be obtained by combining local staples. Unfortunately, the traditional methods also used in the preparation of these foods are accompanied by severe nutrient losses, which affect the nutrient quality of the diet, leading to a vicious circle of malnutrition and infection, possibly leading to death, resulting in high mortality and morbidity among weaning-age children (Mensa-Wilmot *et al.*, 2001).

Malnutrition is a major health problem in developing countries among children, which contributes to infant mortality, poor physical and intellectual development of an infant, lowered resistance to disease, and consequently stifles development. Protein-energy malnutrition occurs as a result of the unavailability of low-cost, high-quality food for low-income earners. This has led to the formulation and development of nutritious complementary foods from local and readily available food crops such as sweet potatoes (Mais and Brennan, 2008).

Sweetpotato (*Ipomoea batatas L*.) is one of the world's most important, versatile, and underexploited food crops (Olatunde *et al*., 2016). The sweetpotato (SP) tuber grows underground, ranges in flesh colour of pink to yellow, purple, or orange and is high in soluble carbohydrates, minerals, and vitamins. It plays an important role in improving household and national food security, health, and the livelihoods of poor families in Sub-Saharan Africa (International Potato Center, 2013).

Nigeria is the number one producer of sweet potatoes in Africa with an annual output of 3.36 million metric tons and is globally the second largest producer after China (FAO, 2000). The crop is grown for both human and animal consumption. It is the only crop among the root and tuber crops that has a positive per capita annual rate of increase in production in Sub-Saharan Africa. Food and Agricultural Organization (FAO) estimates of average potato yield of 5 to 8 t/ha are similar to the estimates from a survey conducted by State Agricultural Development Projects (ADPs) in Nigeria, which reported yields of popular local varieties of 7 t/ha in the south-eastern zones, 3.5 t/ha in the northern zone, and 7 to 8 t/ha in Plateau and Bauchi States (Tewe *et al.*, 2003). This study was carried out to assess the mineral composition of formulated sweet potato weaning foods.

MATERIALS AND METHOD

Sample Collection

Sweet potatoes (*Ipomoea batatas*-orange species) soy-beans (*Gylcine max*), Groundnut (*Arachis hypogaea*), crayfish (*Astacus Fluviatilis*) and dry-smoked catfish were all purchased from Eke-Awka market in Anambra State.

Sample Preparation

Sweet Potato: Exactly 8kg of sweet potatoes were weighed, washed, and then de-shelled. It was then cut into smaller pieces and weighed again which it now weighed 6kg. After which it was washed and cooked for 25 minutes in boiling water. It was then removed, sun-dried for 48 hours, and oven-dried at 70^{o}C for 24 hours. After which, it was blended, sieved, and packaged in an airtight container until use.

Soybean: The 2 kg of soybean was weighed, sorted, washed, and soaked for 3 hours. Thereafter, it was de-shelled and parboiled in boiling water for 30 minutes, after which it was de-shelled again before being sun-dried for 24 hours and oven-dried at 70^{o}C for 24 hours, making 48 hours of drying. This was then blended and sieved; it was then packaged in an airtight container until use.

Crayfish: Exactly 300g crayfish was weighed, then sorted and sun-dried for 48 hours, after which it was blended, sieved, and packaged in an airtight container until use.

Groundnut: A weight of 510g of groundnut was sorted and soaked for 30 minutes in slightly salty water, thereafter sun-dried for 48 hours. After which, it was blended and packaged in an airtight container until use.

The Fish Meal: The smoked fish weighing 500g was broken open and the head and some unwanted parts removed. It was pounded into pieces in a mortar using the pestle and sun-dried for 48 hours, after which both flesh and bones were blended, packaged, and kept for use.

The mineral analysis was determined using the Buck Scientific Flame Atomic Absorption Spectrophotometer.

RESULT AND DISCUSSION

Table 1 shows the sodium content ranged from 67.27-67.84mg/100g. There was a significant difference between the formulated samples and the control. The sodium content of the formulated food sample was higher than the control. Sodium is normally consumed in the form of salt. It is essential for the regulation of water content and in maintenance of the osmotic pressure of the body fluid (Okaka, 2010).

Potassium content shows a significant difference ($P<0.05$) across the formulated sweet potato weaning food blends and the control sample. Sample A (42.29mg/100g) was the highest among the formulated blends and was comparatively higher than the control sample (15.75mg/100g). The result is in agreement with the report of Laryea *et al.* (2018). It also falls short of the Recommended Dietary Allowance (RDA) of 60-160mg/100g day needed in children and infants (Koletzko *et al.*, 2008). Potassium is important in the body for the regulation of fluid, muscle control, and normal functioning of the nerves (Nieman & Butter, 1992).

The magnesium content obtained from the study shows there was no significant difference ($P<0.05$) in the magnesium content of samples A and B, though a slightly higher value was observed in sample A. The values were comparatively higher as compared to the control sample. This could be due to the blending effect, which might have increased the magnesium content (Laryea *et al*, 2018). Magnesium is needed in the body of an infant for a healthy immune system, strong bones, and to regulate blood sugar levels, thereby promoting normal blood pressure (Arinathan et al, 2003).

The phosphorus content of the blends ranged from 425.04 to 446.22mg/100g and was comparatively higher than the control sample with respect to samples A and B. It also fell short of the RDA of 200-1000mg a day needed in children and adults. Phosphorus is important for the synthesis of phospholipids and phosphor-proteins, viz., healthy bones and teeth (Jeremiah et al., 2017).

Calcium content of the formulated blends ranged from 8.38 to 9.05mg/100g and was comparatively lower than the control sample (10.16mg/g). Most of the commercial weaning foods are fortified, which could be a reason for the relatively high calcium content. The value fell short of the FAO/WHO recommendation of 210-500mg/100g.

Calcium forms a major component of bones, assists in tooth development, and plays a role in blood regulation (Okaka, 2005).

Table 1: Mineral Analysis of Formulated Sweet Potato Weaning Food

		Mineral	**(mg/100g)**		
Sample	**Na**	**K**	**Mg**	**P**	**Ca**
A	67.84 ± 0.00^d	45.29 ± 0.01^d	67.37 ± 0.00^c	446.22 ± 0.02^d	9.05 ± 0.07^c
B	67.59 ± 0.12^c	40.23 ± 0.01^c	67.27 ± 0.01^c	436.85 ± 0.09^c	8.78 ± 0.00^b
C	67.27 ± 0.35^b	39.17 ± 0.00^b	66.44 ± 0.01^a	425.04 ± 0.01^a	8.38 ± 0.04^a

D	66.95±0.01[a]	15.75±0.01[a]	66.92±0.09[b]	429.26±0.00[b]	10.16±0.08[d]
LSD	0.18	0.03	0.14	0.14	0.16

CONCLUSION

The study shows that formulated sweet potato weaning foods may serve as a good substitute for commercial weaning foods in the Nigerian market and in developing countries to improve the nutritional status of infants and help curb protein and energy malnutrition.

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IMPROVING NITROGEN USE EFFICIENCY (NUE) IN CASSAVA (*MANIHOT ESCULENTA* CRANTZ) FOR SUSTAINABILITY RESILIENCE AND PRODUCTIVITY

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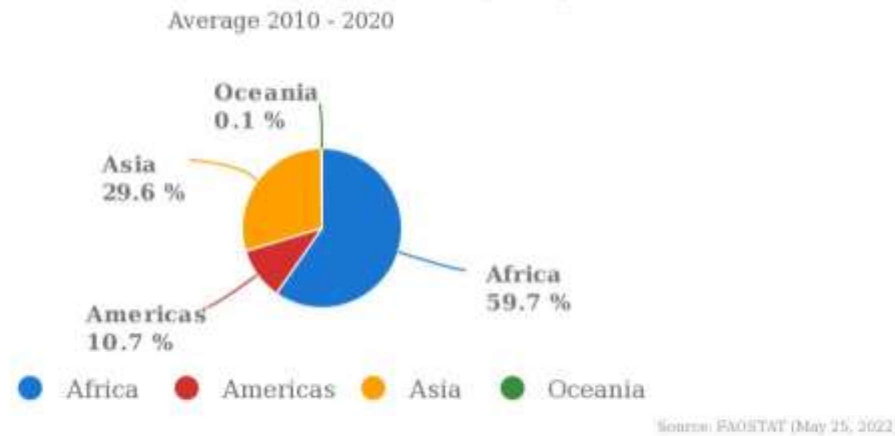
ABSTRACT
Nitrogen (N) is an important ingredient for the overall growth and development of all crop plants. Studies have shown that crops only utilize 50% of the applied nitrogen (N) in an efficient manner; the remaining 50% is lost through numerous pathways to the environment. Nitrogen loss pollutes the water body, soil, air and contributes to increased greenhouse gas emissions. Similarly, nitrogen fertilizers are usually costly and have a detrimental effect on the farmer's return on investment. In crop improvement programmes, increasing nitrogen use efficiency (NUE) is an important breeding objective. Nitrogen is highly mobile in the soil; volatilization, surface runoff, leaching, and denitrification of N are all responsible for low nitrogen uptake by plants. Therefore developing cassava variety with improved N uptake and utilization has become very fundamental since it would reduce the demand for extensive N application and reduce the damaging effects of N on the environment. Nitrogen use efficiency (NUE) is a polygenic trait, controlled by many genes, therefore, conventional breeding method, modern genomic tools, and high-throughput technology can be leveraged to engineer cassava varieties that respond to low-nitrogen tropical soils where cassava are predominantly grown. These would translate to a reduction in the economic and environmental costs of cassava production.
Keywords: *Cassava, nitrogen use efficiency, environment, sustainability, and productivity.*

INTRODUCTION
There is a lot of demand on arable land to produce more food and energy per unit area as a result of the pressure posed by the increasing global population. Agricultural practices must both intensify productivity and simultaneously protect the environment, human and animal welfare in order to achieve sustainable production. This approach includes improving the crop's nitrogen use efficiency (Xiong *et al*., 2018). According to IFAD (2021), over half of the entire world's arable land is degraded, and as a result, not all crops may be supported by its soil. The area of degraded soil is increasing at a rate of 12 million hectares annually or nearly 23 hectares per minute. The severity of the deterioration is endangering rural residents' livelihoods and access to food in addition to rendering the soil unprofitable. As a result, crops grown using artificial nitrogen (N) fertilizers contribute to the sustenance of over half of the global population (Zhang *et al*., 2015).
Nitrogen (N) is a key constituent of all living cells and is essential for the growth and development of plants. Nitrogen Fertilizer is the second largest requirement after water in crop production, and N is the most common yield-limiting nutrient in crop production (Marschner, 1995). Thus, the exogenous nitrogen supply, together with other essential nutrient elements, has allowed farmers to maximize genetic yield potential and boost crop productivity while satisfying the escalating need for food. Nonetheless, irrespective of the part of the world or crop genotype, crops do not use up to 50% of the nitrogen fertilizers applied to the field. The sustainability of ecosystems is now at risk as a result of the devastating effects of this nitrogen oversupply. The cultivation of cassava using inorganic nitrogen fertilizers has significantly increased the cost of production, caused soil acidification, more greenhouse gas emissions, and raised the level of nitrate in water bodies, all of which have severe adverse consequences on both the environment and humans (Behera et al., 2013; Ward *et al*., 2018).
As crop nitrogen recovery efficiency is less than 33% (Raun and Johnson, 1999), it is fundamental to boost the nitrogen use efficiency (NUE) of the crop, as an improvement in nitrogen use efficiency will not only decrease the excess nitrogen that gets to the cropland but also reduces nitrogen-provoked pollution in the environment (Norton *et al*.,

2015). Cassava (*Manihot esculenta* Crantz) has become one of the fastest-growing staple food crops in many regions of the world where it is cultivated and has continued to gain prominence globally, occupying a central place in food and feed industries that drive economic growth (FAO, 2018).

Fig 1.1 Production share of cassava by region



Cassava can be put to multiple uses, and the derived end products are essential in meeting the priorities of developing countries. World cassava production is estimated at 300 million metric tons; forty out of fifty-three countries on the African continent cultivate cassava, which amounts to more than half of the total cassava produced globally (FAO, 2019). In African sub-regions, where cassava is the major source of food for a huge proportion of people, yields have declined by 0.024t ha-^{1} year-^{1} (FAO, 2016). Nigeria's cassava production stands at approximately 60 million metric tons (FAOSTAT, 2019). Despite being the world's largest cassava producer, domestic consumption accounts for more than 90% of total cassava production (Denton *et al.*, 2004).

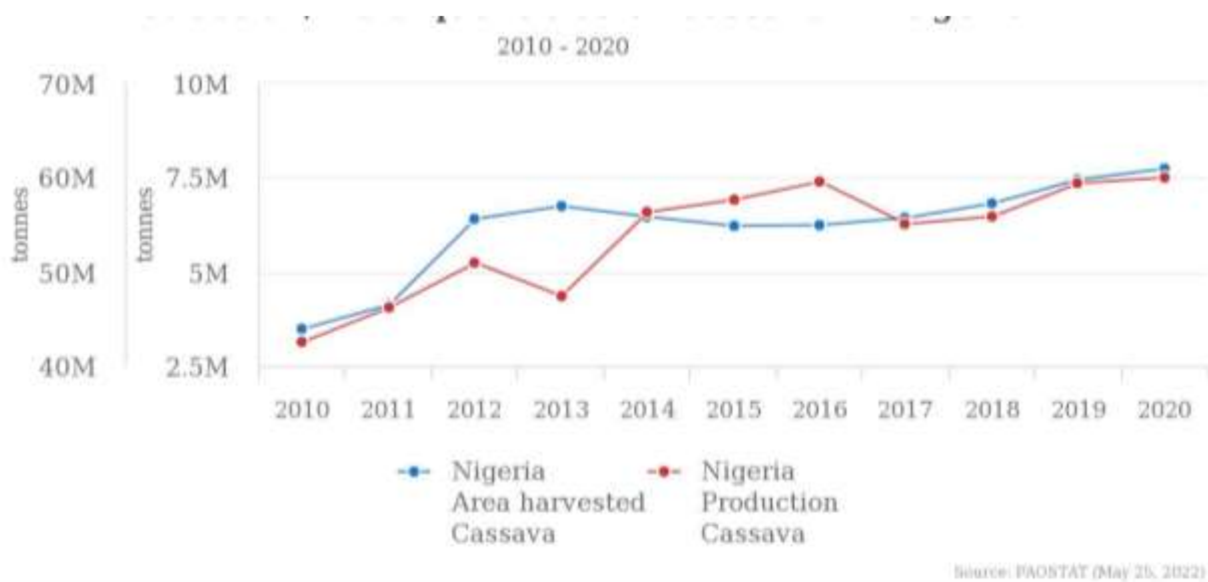


Fig 1.2a Production\Yield quantities of cassava in Nigeria

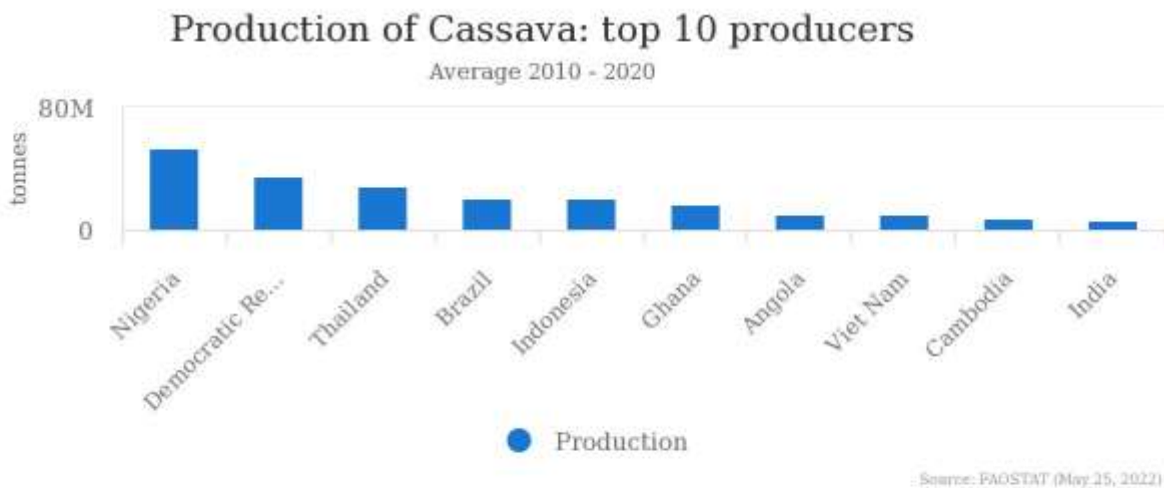


Fig 1.2b Top 10 cassava producers in the world

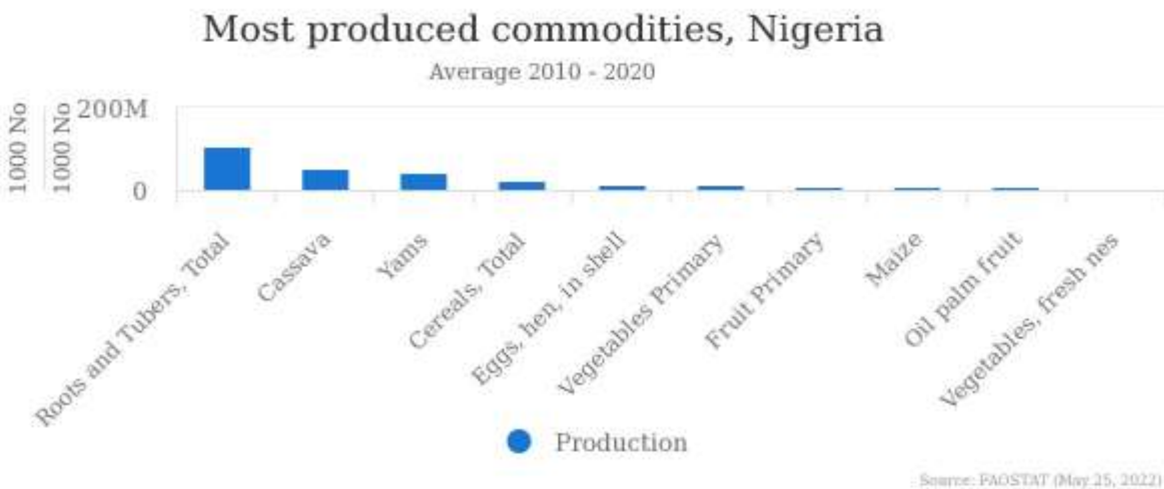


Fig 1.2c Cassava is the most produced commodity crop in Nigeria

Nitrogen fertilizer is the most commonly used nutrient and serves a crucial function in contemporary agriculture, especially in tropical ecosystems. In recent times, its demand has been on the rise because crop yields must be increased to sustain the expanding human population. Notwithstanding the cost, environmental pollution (Wang *et al.*, 2014; Shen *et al*., 2017), and pathogen infection (Huber and Thompson, 2007) challenges posed by nitrogen overuse, the nutrient element whose form is most limiting is nitrogen in tropical regions of the world where cassava is grown (IFDC, 2005; Hartemink, 2006). It is very mobile when applied to the soil, and crops are able to use only a small fraction of applied nitrogen fertilizers; only about half is utilized by crops (Raun and Johnson, 1999). Approximately 50% of fertilizer applied is lost to the environment, as a result of surface runoff, leaching, and volatilization.

Fertilizers of chemical origin usually have low use efficiency, which means that not all of the nutrients given to plants are absorbed (Adesemoye *et al.*, 2009). According to estimates, the overall effectiveness of chemical fertilizer applied to plants is less than 50% for N, lower than 10% for P, and about 40% for K (Baligar *et al.*, 2007). Plant genotypes that efficiently absorb and use applied nutrients save input costs and decrease nutrient losses to ecosystems. Plant interactions with environmental factors cause both intra- and inter-specific variance for mineral nutrient utilization efficiency (NUE) and growth of plants, which is known to be under physiological control and genetic and are further dependent on the interaction of plant and environmental variables. Very little work has been done to understand the variability in nutrient use efficiency that exists in the cassava gene pool. Among the macro-elements, nitrogen is an essential nutrient in crop production and cannot be substituted with any other nutrient element. Nitrogen-deprived plants truncate biomass and leaf elongation (Marschner and Marschner, 2012), retards photosynthetic activities and processes (Gregoriou *et al.,* 2007), reduces the size of chloroplast (Li *et al.*, 2013), and limits the overall plant *growth*. Yet, the majority of nitrogen added to crop systems frequently has little effect on productivity.

According to Borlaug and Dowswell (2005), nutrient-efficient crop genotypes will play a major role in sustaining crop productivity, mainly due to the high cost of inorganic fertilizer inputs and increasing environmental concerns. Breeding initiatives must concentrate on creating cultivars with high NUE. The efficiency of nutrient utilization should be considerably increased by identifying traits like mobilization, absorption, and use of nutrients in plant genotypes (Roberts, 2008). Developing nitrogen-efficient novel cassava varieties through the exploitation of genetic diversity with improved crop genetics and better agronomic practices would aid in increased crop productivity (Sandhu *et al.*, 2021). There are three key components to nitrogen absorption by plants: uptake, assimilation, and remobilization (Han *et al.* 2016), and these processes are governed by several cryptic genetic and physiological mechanisms. The efficiency of nitrogen utilization is defined as the capacity of the cassava genotype to grow, develop, and reproduce in the presence of nitrogen nutritional deficits in the soil (Fritsche-Neto *et al.,* 2010). Nitrogen use efficiency (NUE) is the result of nitrogen uptake efficiency (NUpE) and nitrogen utilization efficiency (NUtE) (Good *et al.,* 2004). Reports have shown that increased NUE has a positive significant correlation with crop biomass and yield (Stanley *et al.*, 2006; Wu *et al.*, 2016). This implies that selection based on NUE can enhance cassava productivity. Kant *et al.* (2011) also claimed that a 1% improvement in NUE may result in annual savings of $1.1 billion. Thus, in order to limit the cost of input, environmental contamination, and loss of plant nutrients, and reduce emissions of greenhouse gases, it is salient to breed cassava varieties with improved nitrogen use efficiency that can respond to low soil nitrogen.

Nitrogen use efficiency (NUE) is an index used to comprehend the connections between total nitrogen input and nitrogen output. Farmers will often apply excess nitrogen despite the high cost of fertilizer and perceive that all nutrients applied would translate to increased yield (Sheriff, 2005). However, not all nutrients applied to the soil are utilized by the crops; hence identification of cassava genotypes with enhanced nutrient use efficiency would save production costs and pollution in the environment associated with nitrogen overdose.

Contemporary approaches that can be adopted in crop improvement include traditional marker-assisted breeding, which involves the genetic mapping of genomic loci linked with the trait of interest in a segregating population or diversity panel and exploiting them upon functional validation in marker-assisted selection. Genome-wide association studies (GWAS) are generally used to study complex polygenic traits and identify QTL regulating variation in quantitative agronomic traits. This approach has been exploited to gain a genetic understanding of the processes associated with NUE-related phenotypes in several crop species (Liu *et al.,* 2016; Morosini *et al.,* 2017; Monostori *et al.*, 2017). However, not many GWAS studies have been applied to the diversity panel of cassava for agronomic traits (Shengkui *et al.,* 2018), and none for NUE-related traits.

In most studies on crops' performances under various treatment conditions, the correlation of traits with respect to nitrogen use efficiency will always show significant interaction with the environment under study, a clear indication that different results could be derivable within the same selection parameter under high or low nitrogen regimes (genetics by environmental interaction), Many studies suggest that selection of genotypes within target environment can be helpful, more especially for low nitrogen regimes (Lammerts van Bueren and Myers, 2011). Plant genomics primarily focuses on discovering the biological roles of genes; it bridges the genotype-phenotype gap; it aids in understanding not just the solitary impact of a gene but also how its genetic and environment interact with one another to modify its activity (Campos-de Quiroz, 2002). Genomics focuses on the science and technology of genome organization by combining three areas of study (Tinker, 2002; Johnson, 2004).

These studies include genetics, which is also defined as the investigation of the particulars of inheritance. The second part, which consists of automated lab equipment for high-output protein analysis (DNA and RNA), depends on the expanding knowledge of the biochemistry of nucleic acids. Lastly, the third area is molecular genetics and information, where information science is used to locate and align gene sequences in order to confirm how genes and gene products interact to construct genetic networks. This field is centered on the convergence of mathematics, statistics, biology, and computer science. In addition to offering methods for predicting phenotypes from gene sequences and related data, bioinformatics also reveals the molecular description of the genetic origins of phenotypes.

In cassava, nitrogen utilization efficiency is a complicated, quantitatively inherited characteristic that contributes to storage root yield. Knowing how quantitative features are inherited would help breeders choose the best breeding strategy. Mating design is a set of guidelines for organizing various regulated crossings as well as a process for creating offspring. Through mating designs, information is provided for evaluating parents' general combining ability (GCA) and specific combining ability (SCA), as well as estimates of genetic parameters and genetic gains (Klein *et al.,* 1973). Low adoption occurs as a result of certain enhanced cultivars not always meeting farmers' needs. According to earlier studies, farmers' demands are not being met when better crop varieties are not adopted widely (Manu-Aduening *et al.*, 2006). Local cultivars are still being grown by farmers because they meet their immediate needs but are often low-yielding and vulnerable to biotic and abiotic stressors (Sam and Dapaah, 2009; Manu-Aduening *et al*., 2007).

Improving the cassava fresh root yield of farmer-preferred varieties and increasing the acceptability or adoption of new cultivars will assist other stakeholders and farmers in increasing productivity and profit (Manu-Aduening *et al.*, 2014). This will necessitate gathering information on farmer preferences for new varieties. Any breeding program must begin by gathering data on farmers' perception of production challenges, preferences, and selection criteria for new genotypes (Efisue *et al*., 2007: Joshi and Bauer, 2006). Contrary to strict on-station breeding, getting farmers to participate in the identification and mitigation of perceived production constraints has led to a more coordinated breeding procedure and a higher success rate (Manu-Aduening *et al.*, 2014).

Finally, involving farmers in the development of varieties speeds up the spread and adoption of such varieties. Nitrogen-efficient cassava genotypes would increase smallholder farmer's income, and preserve the soil environment from nitrogen-based pollution since half of the external nitrogen applied to crop land is usually lost through various pathways to the surrounding environment. Hence developing resilient cassava varieties with improved nitrogen use efficiency should be given priority attention by all stakeholders.

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A REVIEW -POTATO (*SOLANUM TUBEROSUM* L.) A SOURCE OF FOOD AND NUTRITION SECURITY ON THE HIGHLANDS OF NIGERIA.

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ABSTRACT
Majority of undernourished people in Africa are found in the sub-Saharan sub region with high levels of poverty, hunger and malnutrition. Potato is the fourth most important staple crop after maize, rice and wheat, and among the oldest crop grown globally. The crop plays a significant role in addressing food and nutrition security in both rural and urban areas, increasing farmer's income and reducing poverty level of the household due to its high yield, excellent food value and early maturity. It is a good source of carbohydrates, proteins, vitamins, minerals, dietary fiber and phytochemicals. The crop provides 75 % more food energy per unit area than wheat and 58 % higher than rice. The protein content in potato is higher than that of animal origin like milk and beef; and has more protein per unit area than wheat and rice. Potato contains 57mg phosphorus, 425mg potassium and 23mg magnesium per 100g of fresh weight. The vitamin C content ranged from 13-30.8 mg per 100g tuber and higher quantities than other vegetables like pumpkin, onion and carrots. Potato has a promising prospect in improving food and nutrition security in both rural and urban areas. Therefore, promoting potato production can alleviate food insecurity, combat micronutrient deficiency, enhance household income and hence reduce poverty level among the farming communities.
Keywords: *Potato, food security, nutrition security, malnutrition*

INTRODUCTION
Potato (*Solanum tuberosum* L.) is believed to have originated from the highlands of Peru and Bolivia (Acquaah, 2012). It is the most popular nutritious vegetable and among the oldest crop grown for food worldwide (Sahair *et al*., 2018; Nityamanjari, 2018; Reddy *et al*., 2018). The crop was rapidly distributed into the world due to its potentials for providing food, preservation and eradication of poverty (Bradshaw and Bonierbale, 2010). Potato is the fourth most important staple crop after maize, rice and wheat, and is consumed by more than a billion people as a staple food worldwide (Zaheer and Akhtar, 2016; CIP, 2014; Nasiruddin *et al*., 2017). It is cultivated in more than 161 countries globally, on an area of 25 million hectares (Tessema *et al*., 2022). The estimated total world production stood at 388.2 million tons, Africa and Nigeria production was estimated at 25,011.800 million tons and 1,284,368 million tons in 2017 respectively (FAO, 2019). In developing of countries of Asia and Africa, increase in potato production is still high due to its importance as a staple food crop (Anonymous, 2016).

The major potato producing areas in Nigeria are located at the highlands of Jos, Plateau State, Mambilla Plateau, Taraba State, Obudu, Cross River State and Biu, Borno State with suitable climatic and edaphic conditions. The crop is mostly grown under rain fed and irrigated conditions, however, recent data revealed that potato can also be grown in some lowland areas of Northern Nigeria under adequate irrigation during the harmattan period. The crop plays a significant role in addressing food security and produce a large amount of food on small area of land (Jansky and Spooner, 2018). Potato is a high potential food security crop with good source of carbohydrates, rich in proteins, vitamins, minerals, dietary fiber and phytochemicals.

The nutrient rich potato can improve food security and health, especially among women and children, thus, reducing mortality rate cause by malnutrition (Kumari *et al*., 2018). Potato is an ideal food for both developed and developing countries due to its ability to be stored for long period of time with minimal technological inputs (Bradeen and Hayes, 2011). Availability of potato 60-120 days after planting as compared to other root and tuber crops confer advantage of double cropping during the rainy season, valuable source of food security and a sustainable source of income for those in production, processing and marketing of the crop. Potato can play a significant role in combating malnutrition which is a major challenges confronting many developing countries where most of the staple food crops are deficient in micronutrients. This current review looks at the contribution of potato in alleviating hunger, malnutrition and poverty in the rural and urban communities in Nigeria.

Contribution of Potato to Food and Nutrition Security

Majority of undernourished people in Africa are found in the Sub-Saharan sub region (FAO, IFAD, WHO, UNICEF, WFP (2020), of which Nigeria is inclusive. Potato is contributing to food and nutrition security of these highlands population through enhancing the quality of the basic diet, thus reducing mortality rate caused by malnutrition, increasing household income as a cash crop and hence reducing poverty levels in both rural and urban areas. Potato potential for higher yield per unit area, short period, and excellent food value is an important option for food security in many developing nations (Semahegn Asredie *et al*., 2015; Tessema *et al*., 2022). It is considered one of the most profitable food crops after rice and maize for the farmer (FAO, 2019). Majeed and Muhammad (2018), reported that potato is consider as one of the major vegetable and predominantly referred to as King vegetable as it produces more dry matter and protein per hectare than major cereal crops (Singha and Ullah, 2020; Storey, 2007). Potato has come to be a basic parts of breakfast, lunch and dinner among rural and urban populations and consumed in various forms like baked, roasted, boiled, fried and or in processed forms like chips, French fry, and potato powder (Nanbol and Timothy Namo, 2019; Farzana *et al*., 2021).

Stevenson *et al*., 2001, highlighted that potato cannot be match up with other food crop, not even soybean for production of food energy and food value per unit of land area. When compared to other potential food crop, potato provides more carbohydrates, proteins, minerals and vitamins per unit area of land (Zaheer and Akhtar, 2016). The crop contains 70-82 % water, 17-29 % dry matter, 11-23% carbohydrates, 0.8-3.0 % protein, 1.1 % mineral and 0.1 % fat (Nityamanjari, 2018). When boiled and eaten with its skin, 150g medium sized potato provides about half of the daily adult requirement of vitamin C, and 10% of the recommended daily intake of fibre (Panigrahi *et al*., 2017; Devaux *et al*., 2020). Kharumnuid *et al*. (2021), reported that there are approximately, 2.05g of protein in a 100 g fresh potato tuber, and provide more protein than maize with nearly twice the calcium when boiled (Panigrahi *et al*., 2017). Starch is the predominant aspect of carbohydrates in potato and supplied most of the energy obtained, and makes up 15-20 % on fresh weight and 60-80 % of the dry matter. Potato has 75 % more food energy per unit area than wheat and 58 % higher than rice (Nanbol and Timothy Namo, 2019).

Protein content in potato is of higher quality, higher than other major roots and tubers, major cereals and moreover, higher that proteins of animal origin like milk and beef (Singh *et al*, 2020). It has 54 % more protein per unit area than wheat and 78 % more than rice (Nanbol and Timothy Namo, 2019). Dereye and Chibuzo (2021) stated potato can provides 7 %, 6 % and 5% of daily energy, and 12%, 11%, and 10% of daily protein requirements for children aged 1-2, 2-3 and 3-5 years respectively. Potato contains minerals such as iron, potassium, phosphorus, and magnesium, and also folate, pantothenic acid, and riboflavin and source of vitamin B_1, B_3 and B_6. (Devaux *et al*., 2020). It is a good sources of iron and folic acid, which are very crucial for formation of red blood cells (Sahair et al., 2018). The crop contains 57mg phosphorus per 100g edible portion, 425mg potassium, and 23mg magnesium per 100g of fresh weight basis (Singh *et al*., 2020). The vitamin C or ascorbic acid content in potato ranged from 13-30.8 mg per 100g tuber (Dereye and Chibuzo, 2021). It contains high quantities of vitamin C than other vegetables like onion, pumpkin, and carrots and rich in dietary fibre which help in lowering cholesterols level, the dietary fibre ranged from 1-2g per 100g of fresh weight (Singh *et al*., 2020).

Potato contains phytochemicals with good medicinal potentials and contributes the highest antioxidant to human diet (Wijesinha and Mouille, 2019). These phytochemicals are known to help in neutralizing cancer cell, reduce blood cholesterol level, heart diseases and eye cataracts (Astley, 2005; Brown and Brown, 2005). Furthermore, potato are also used for the treatment of prostate and breast cancer, and stomach ulcers due to higher antioxidant content (Kumari *et al*., 2018; Ogbuagu *et al*., 2020), and consumption of potato are known to increase milk production in lactating mothers (Ahmed *et al*., 2015). Attributed to its correct balance between protein and calories, potato is considered a good weaning food (Bezabih and Mengistu, 2011). Similarly, Nanbol and Timothy Namo (2019) reported that potato is nutritionally considered to be a well-balanced food crop with good ratio between protein and calories, rich in essential vitamins especially vitamin C, minerals and trace elements, hence, it is a wholesome major food crop that one can live by eating potatoes alone (Singh *et al*., 2020). Potato production in the highlands is constricted to small farm size and its labour requirement is less when compared to other crop like cereals. It is a transitional crop as it's matures earlier, which enable farmers survive the hunger months that occur during the rainy season. Potatoes are consumed in most urban centres of the country, where more than 85% of the biomass are edible, when weigh against other food crops like cereals.

CONCLUSION

Potato has a great potentials for sustainable food supply, in less time and less area. . It is a good source of carbohydrates, protein, vitamins, minerals, dietary fiber and phytochemical and a promising prospect for achieving food and nutrition security in both rural and urban areas. Therefore, promoting potato production can alleviate food insecurity, combat micronutrient deficiency, enhance household income and hence reduce poverty level among the farming communities in the highlands in particular and the country in general.

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RESPONSE OF WATERMELON (*CITRULLUS LANATUS)* TO PIG MANURE IN OWERRI, SOUTH EASTERN NIGERIA

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ABSTRACT
Field experiments were conducted in 2020 and 2021 cropping seasons in the Teaching and Research Farm, Agricultural Science Department, Alvan Ikoku Federal College of Education, Owerri, Imo State, Nigeria to evaluate the response of watermelon to four rates of pig manure. The investigation was carried out in a Randomized Complete Block Design with three replications. Treatments was composed of pig manure rates of 0, 5, 10, 15 tons per hectare. Parameters studied were number of leaves per plant, vine length per plant, number of fruits harvested per plant and weight of harvested fruits per plant. Data collected were subjected to Analysis of Variance (ANOVA) and significant treatment means were separated using Least Significant Difference (LSD) protocol. Results obtained from the two experiments conducted showed that plants that received application of pig manure at the rate of 15 tons per hectare gave the best performance in all the parameters studied and is therefore to recommended for watermelon cultivation in Owerri, South Eastern Nigeria.
Keywords: *Watermelon, pig manure,*

INTRODUCTION
Watermelon (*Citrullus lanatus*) is a crop with huge economic importance to man (Schippers, 2000). The fresh fruit is relished by many people across the world. It is a nutritious, sweet, thirst-quenching fruit. Watermelon like most vegetables is widely cultivated in the Northern Nigeria but greatly consumed in the Southern Nigeria (Poly-Mbah, 2008, 2012b). Farmers incurred a lot of losses in transporting watermelon fruits from Northern Nigeria where it is produced to Southern Nigeria where it is consumed (Poly-Mbah, 2010a ,2010b and 2012a) This is responsible for the high market price watermelon command in South eastern Nigeria. There is a need for massive watermelon production in the South Eastern Nigeria where it is highly consumed.

Some researchers have published reports on the use of poultry manure for the production of watermelon in South Eastern Nigeria (Enujieke, 2013) but the sustained release of nutrients is a challenge. Hence, the need to investigate the production of watermelon fruits in South Eastern Nigeria using pig manure.

It has been reported that pig manure is effective as a good source of nutrients for sustainable crop production (Enujeke et al, 2021). Research findings have revealed that the application of swine waste (pig manure) at the rate of 20 tonnes/ha could lead to toxic levels of sulphate in crop produced (Mbah et al., 2005). There is a need therefore to determine the pig manure requirement of watermelon in Owerri, South Eastern Nigeria.

MATERIALS AND METHODS
The two experiments were conducted in the Department of Agricultural Education Teaching and Research Farm, Alvan Ikoku Federal College of Education in 2020 and 2021 late session cropping. The site has been under the cultivation of vegetable crops for considerable number of years.

The field experiments were laid out using the Randomized Complete Block Design with three replications. Treatments were four rates of pig manure (0, 5, 10, and 15 tons/ha). Agronomic measurements taken were number of leaves per plant, vine length per plant, number of vine branches/plant number of mature fruits harvested per plant and weight of harvest fruits per plant. Data collected were subjected to Analysis of Variance (ANOVA) test and significant treatment means were separated using the Least Significant Difference (LSD).

RESULTS AND DISCUSSION

Results obtained showed that plants that received 15 tons/ha of pig manure were outstanding in terms of number of leaves/plants (Table 1) vine length/plant (Table 2) at 4, 6, and 8 weeks after planting (Table 1). This confirms the publication made by Aliyu, 2000 who stated that pig manure contains useful proportions of essential and major nutrients that sustains plant growth.

Table 1.- Effects of Pig Manure on Leaf Number at 4,6,8, and Weeks after planting

	2020 4 WAP	2021 4 WAP	2020 6 WAP	2021 6 WAP	2020 8 WAP	2021 8 WAP
T1	10.10	13.53	13.30	25.76	16.10	30.40
T2	16.20	31.63	22.30	33.53	26.50	35.86
T3	21.10	23.30	26.40	34.43	28.30	38.74
T4	25.50	33.96	28.50	39.63	31.10	42.96

LSD	**4 WAP**	**6 WAP**	**8 WAP**
2020	0.30	0.40	0.30
2021	0.52	0.28	0.17

Table 2.- Effects of pig manure on the vine length cm of the watermelon at 4,6 and 8 weeks after planting.

	4 WAP		6 WAP		8 WAP	
	2020	2021	2020	2021	2020	2021
T1	16.32	25.73	31.21	31.73	41.44	61.40
T2	60.38	56.40	117.44	70.30	137.24	148.53
T3	73.98	34.60	131.30	81.83	155.47	165.20
T4	79.96	58.93	162.46	89.73	201.36	187.06

LSD	**4 WAP**	**6WAP**	**8 WAP**
2021	0.5	0.7	0.8
2022	11.02	7.04	14.0

Data obtained on the number of harvestable fruits and weight of harvested fruits showed that the plants that received 15 tons/ha performed best among other treatments (Table 3). This result shows that application of pig manure at the rate of 15 tons/ha not only improved the soil conditions for watermelon establishment but also released adequate nutrient elements for yield enhancement. This finding is in line with reports made by Adekiya and Ojeniyi 2002, Mangila et al., 2008 and Enujeke et al., 2021.

TABLE 3
Effects Of Pig Manure On Fruit Member Per Plant And Fruit Weight (Kg) Per Plant At Harvest

	Fruit Number		Fruit Weight	
	2021	2022	2020	2021
T1	**1**	**1**	**3.31**	**2.13**
T2	**2**	**2**	**6.43**	**5.73**
T3	**3**	**4**	**8.74**	**6.93**
T4	**4**	**6**	**10.07**	**8.0**
LSD	**Fruit number**		**Fruit weight**	
	0.1	**0.15**	**0.3**	**0.2**

CONCLUSION AND RECOMMENDATIONS

The investigation here reported confirmed that the application of pig manure significantly affected all the parameters studied such that the pig manure rate of 15 tons gave the highest values in all the parameters studied and is therefore recommended.

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HEALTH AND SAFETY OF FOODS SERVED BY FOOD VENDORS ON CAMPUSES OF KADUNA POLYTECHNIC

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ABSTRACT

Investigation into health safety of foods served by food vendors on the campuses of Kaduna Polytechnic was carried out. The research is aimed at investigating the safety of food sold by food vendors on how food safety management could be achieved. A total of 16 samples, 4 samples each of the campuses were collected. The samples were subjected to total plate count (enumeration of mesophilic Aerobic Bacteria), coliform count, yeast and mould count and gram staining for the identification of microorganisms isolated. The result of total plate count reveals colony count of $<1.0X10^2$ to 2.7×10^4 with sample CB having the highest. While sample SA and TA showed no growth of mesophilic aerobic bacteria. The result for coliform bacteria indicated no growth for 11 samples while 5 samples were positive for coliform bacteria which ranges from $1.5x10^2$ to 6.5×10^2. The result for yeasts and mould count revealed 13 sample were negative for yeasts and moulds while only 3 recorded growth for yeast and mould which ranges from $<1.0x10^2$ to 1.8×10^3. The isolated organisms were gram stained for possible identification and the result revealed the presence of bacillus species, staphylococcus species streptococci species, coliform species yeast species and mould species respectively. The result reveals that the organisms identified are the common spoilage organisms found in food. Although this study also revealed that most of the vendors had some knowledge of hygiene and safety practices, but they were inadequate. Knowledge insufficiency was presented by 47% and 48% of the respondents who were ignorant of the right temperature to preserve cold foods and the temperature that encourage the growth of bacteria respectively. Therefore, this recommends that, adequate hygiene practice should be carried out daily, foods should be freshly prepared daily and food samples should be subjected to routine laboratory analysis, while training sections are to be enhanced to ensure safety procedures are maintained.

Keywords: Safety of foods, Food vendors, Mesophilic aerobic bacteria, Coliform, Yeast and Mould

INTRODUCTION

Food according to Akintola, (2016) is defined as any substance consumed to provide nutrition support for an organism. Food safety is used as a scientific discipline describing handling, preparation and storage of foods in ways that prevent food-borne illnesses. Ali *et al.* (2011), Arendt (2010) and Evans *et al.* (1998) reported that the street foods are usually sold by vendors or hawkers at street side on cart or on campus small stalls. Street vendors are usually poor, uneducated, lack knowledge of food hygiene and handling, sanitation of the environment, food service, hand washing, source of raw materials and potable water (Khairuzzaman *et al*., 2014). Microbial food borne illness is major health problem associated with street foods, Multi-drug resistant food borne diseases is most common and approximately 30 million people suffer from these illnesses each year in Nigeria (FAO, 2012;Omemu and Aderoju, 2008)

In Tertiary institutions, food safety is affected by the unhygienic handling of foodstuff, health status of food vendors, poor sanitary conditions of markets, absence of adequate waste disposal facilities, use of contaminated water and kitchen equipment and poor food storage. Studies have shown that some food vendors in tertiary institutions engage unsafe hygiene practice (Ferami *et al.,* 2018). Documented reports also indicated that specimen collected from 40 kitchen workers revealed cysts of *Entamoeba histolytica* were isolated in the steel of 23 food producers (Mathee *et al.,* 2008) while salmonella paragraph, the causative agent of Typhoid fever, was also isolated from 3 food handlers (Holtby *et al.,* 2007). Eating away from home, especially in restaurants, has been found to be associated with a significant number of food-borne disease outbreaks in the United States (Gould *et al*., 2013). Therefore, the industry has a role to play in mitigating food-borne' disease outbreaks. Rocourt *et al*. (2003) opined that this can be achieved by addressing food handler related risk factors in these food establishments.

Statement of the Research Problem

Eateries are presently very important in the school and the society as many people eat outside home. It is of utmost importance that every food purchased must be safe for consumption. In spite of the various campaign by the National Food and Drug Agency, various organizations like the World Health Organization, the Federal and State ministries of health on the need for clean food, food safety management is still a challenge among food handlers in the tertiary institutions. In providing a safe food management, there is need for the food centers to practice good hygiene standard.

Objectives of the Study

This study was therefore aimed to investigate health safety of foods served by food vendors on the campuses of Kaduna Polytechnic. The specific objectives of the study are to:

i. To evaluate the level of awareness of food borne pathogens amongst the food vendors.
ii. To ascertain the microbial load of specific organisms found in the food sold in the eateries.
iii. To determine the level of food safety practiced by the food vendors at the eateries of Kaduna Polytechnic.

MATERIALS AND METHODS

The research design adopted for this study was the experimental and survey research design. The study area covered the entirety of the Kaduna Polytechnic four (4) campuses. The population of study comprised of all food vendors including students and staff of Kaduna Polytechnic who were involved in ready to eat food selling business. A multi stage sampling technique was used to select 32 respondents from each of the campuses representing (128) however, only (100) respondents participated fully in the research. A random sampling technique was used to select the food vendors from each campus. A random selection was also made by picking them from the eateries selected following the method of sampling of Fisher *et al.* (1998). The major instruments used for obtaining raw data were a well-structured questionnaire by the researchers and food samples from the vendors. The questionnaire contained 22 questions that were designed to acquire data on food safety management from the selected eateries. The questionnaire was validated at the department of Hospitality and Management Kaduna Polytechnic. Questionnaires were administered personally by the researchers to all the respondents. Freshly cooked food samples were obtained from the vendors, four (4) food samples were collected from each of the campuses making a total of 16 food samples in a mini plastic container to analyze for the safety of which were homogenized and incubated at $37^{o}C$ for 24 hours in the microbiology laboratory for the presence of microorganisms. Plates with identified microbial growth colonies were further isolated to identify specific microorganisms and their microbial load. Data obtained from questionnaire were analyzed using Statistical Package for Social Sciences (SPSS) version 20 and presented using percentage and frequency distribution tables.

RESULTS

A huge number of the respondents (74%) were female with 50% being single. A notable number (45%) of the respondents are between 18 and 25 years of age. Five percent (5%) of the food service staff had no formal education. 12% and 30% respectively had primary and secondary school education. However, more than half 53% of the food service staff had polytechnic and university education. Most 70% of the food service staff acquired their knowledge of food preparation by formal training while few 30% acquired the knowledge through observation. About 4% of the respondents had been in food business for 6 to 10 years; however, only 28% of the respondents had the health certificate to indicate that they have carried out the annual medical checkup while 72% could not present the health certificate.

Table 1. Shows results on the level of awareness of possible food borne pathogens and food borne illnesses amongst the vendors. A remarkable (85%; 60% and 78%) of the food service staff knew that *Salmonella* spp, *Staphylococcus aureaus* and *Vibrio cholera*, respectively are food borne pathogens while 55% of the food service staff did not know whether hepatitis A is a food borne pathogens. 13% disagreed that typhoid can be transmitted through contaminated food and 30% are not aware that abortion in pregnant women can be induced by food borne pathogen. Majority (87%) of the food service staff surveyed know that preparation of food disregarding hygiene rules causes food borne illnesses and (78%) are aware that improper heating of food causes food borne illnesses. The results also revealed the vendors agreed that children, pregnant women, elderly and travelers (91%; 79%; 88% & 78%) respectively were at higher risk of food borne illnesses.

Table 1: Knowledge of food borne pathogens and food borne illnesses.

ITEM	,	TRUE	FALSE	DO NOT KNOW
	Knowledge to possible food borne pathogens			
1.	Salmonella Spp	85	4	11
2.	Staphylococcus Aureus	60	20	20
3.	Hepatitis A	35	10	55
4.	HIV	26	60	14
5.	Vibrio cholera	78	02	20
	Preparation of food disregarding hygiene rules causes			
i.	Food borne illnesses	87	05	08
ii.	Improper heating of food causes food-borne illnesses	78	22	00
iii.	Typhoid fever can be transmitted through contaminated food	77	13	10
iv.	Abortion in pregnant women can be induced by food borne pathogen	23	44	30
	The following people are at higher risk of food borne illnesses			
i.	Children	91	05	04
ii.	Pregnant women	79	07	14
iii.	Elderly/age	88	05	07
iv.	Immune-compromised	58	25	17
v.	Travelers	78	02	20
vi.	Everybody	87	09	04

The results on Table 2. Shows the total plate count for mesophilic aerobic bacteria. The colony forming unit (cfu/g) ranges from No growth to 2.7×10^4 with sample CB (white rice and stew from CBMS) having the highest colony count of 2.7×10^4; followed by sample TC (*eba* and *Ogbono* soup: 2.6×10^3) from CST and sample SB (*Jollof* rice and beef: 2.0×10^3) from CASSS. Others are sample BA (*waina* and *miyan-taushe*: 7.3×10^2) from CES, sample SC (fried rice and beef
; 5.0×10^2) from CASSS. While sample C & CD (cooked beans and stew & *moimoi*) from CBMS had colony forming units $<1.0 \times 10^2$, Sample SA (*semovita* and Ogbono soup from CASSS) and TA (*Jollof* rice and beef from CST) had no growth of bacteria. From the result when compared to WHO and FAO standard of 3.0×10^2, (FAO/WHO, 2022) it can state that sample CB, CA, TC, BD,BC, BA, SC, and SB are above permissible levels of bacteria. Isolated organisms after gram staining discovered the presence of *Bacillus* species, *Staphylococci* species and *Streptococci* species, respectively. These organisms are responsible for food spoilage and food infection.

Table 2a: Analysis on Microbial load and Isolated Organisms

SIN	CODE	SAMPLE NAME	LOCA'I'ION	CFU/g	GRAMS STAINING REACTION	MICROSCOPIC IDENTIFICATION(ORGANISMS ISOLATED)
1	SA	Semovita and Ogbono soup	CASSS	NIL		No Bacteria isolated
2	SB	Jollof'rice and beef	CASSS	2.0×10^3	1.Gram positive rods 2.Gram positive Cocci	1. Bacillus species 2. Staphylococci species
3	SC	Fried rice and beef	CASSS	5.0×10^2	Gram positive rods	Bacillus species
4	SD	Moimoi	CASSS	2.6×10^2	Gram positive rods	Bacillus species
5	BA	Waina and Miyan-taushe	CES	7.3×10^2	1. Gram positive rods 2. Positive Cocci in cluster chain	1. Bacillus species 2. Staphylococci species 3. Streptococci species
6	BB	White rice & stew	CES	1.6×10^2	Gram positive rod	Bacillus species
7	BC	Akpu and Egusi	CES	4.0×10^2	1. Gram positive rod	1. Bacillus species

		soup			2. Gram positive cocci in clusters	2. Staphylococci species
8	BD	Fried rice and beef	CES	4.3 x 10^2	1. positive rod 2. positive cocci	Bacillus species Staphylococci species
9	TA	Jollof rice and beef	CST	NIL		No bacteria isolated
10	TB	FriedPotato/Stew	CST	1.0 x $l0^2$	Gram positive cocci in clusters	Staphylococci species
11	TC	Eba &Ogbono soup	CST	2.6 x 10^3	Gram positive rods	Bacillus species
12	TD	Fried plantain and stew	CST	3.6 x $l0^2$	Gram positive cocci in clusters	Staphylococci species
13	CA	Semovita & Egusi soup	CBMS	1.5 x 10^3	Gram positive rods	Bacillus species
14	CB	White rice & stew	CBMS	2.7 x 10^4	1. Gram positive rods 2. Positive cocci in cluster	1. Bacillus species 2. Staphylococci
15	CC	Cooked beans & stew	CBMS	< 1.0x$l0^2$	Gram positive rods	Bacillus species
16	CD	Moimoi	CBMS	< 1.0x$l0^2$	Gram positive rods	Bacillus species

Table 2b shows the result of total *Coliform* bacteria count. The result indicated that most of the samples had no colony forming unit; however, a considerate number of 5 out of the 16 samples showed the presence of colony forming bacterial ranging from 1.5x 10^2 (the lowest) up to 2.7x10^4 (the highest) for samples TC & CB respectively. The presence of *Coliform* bacteria in food or water is an indication of faecal pollution through direct or remote contamination. Their presence also indicates unhygienic sanitary practices. *Coliform* bacteria are responsible for infantile diarrhea in children.

Table 2b: Coliform Count

S/N	CODE	SAMPLE NAME	LOCATION	CFU/g	GRAM REACTION	MICROSCOPIC ·IDENTIFICATION
1	SA	Semovita and Ogbono soup	CASSS	NIL		No coliform
2	SB	Jollof rice and beef	CASSS	6.5 x 10^2	Gram negative rods	Coliform species
3	SD	Moimoi	CASSS	NIL	--	No coliform
4	BA	Waina and miyan-taushe	CES	2.5 x $l0^2$	Gram negative rods	Coliform species
5	BB	White rice and stew	CES	NIL	--	No coliform
7	BC	Akpu and egusi soup	CES	NIL	--	No coliform
8	BD	Fried rice and beef	CES	NIL	--	No coliform
9	TA	Jollof rice and beef	CST	NIL	--	'No coliform
10	TB	Fried potato and stew	CST	NIL	--	No coliform
11	TC	Eba and Ogbono soup	CST	1.5 x 10^2	Gram negative rods	Coliform species

12	TD	Fried plantain and stew	CST	NIL	--	No coliform
13	CA	Semovita and egusi soup	CBMS	1.7 x l0^2	Gram negative rods	Coliform species
14	CB	White rice and stew	CBMS	2.7x l0^4	Gram negative rods	Coliform species
15	CC	Cooked beans and stew	CBMS	NIL	--	No coliform
16	CD	Moimoi	CBMS	NIL	--	"No coliform

A further investigation into the samples for presence of yeast and mould indicated no growth; however, 3 out the 16 samples indicated the presence of microorganism growth with colonies which ranged from total count of (<1.0 x 10^2), (1.1 X 10^2) & (1.8x10^3) for samples BB, BA and BC respectively. An exploration in to food safety knowledge of food service staff as shown in the Table 3. exposed that 47% and 48% of the respondents were ignorant of the right temperature to store cold ready -to-eat food and the temperature that encourage the growth of bacteria respectively. More so, majority of the respondents 72% erroneously stated that contaminated foods always had a change in colour and odour while only 26% of the respondents could tell that clean is not the same as sanitized. Majority of the food service staff are aware of some safety practices as seen in Table 4. However, a notable percentage 20% could not tell if hands and arm jewelries were a source to food contamination. An additional investigation into food safety practice revealed about 10% of the respondents never wash their foods before cooking while about 43% of the food service staffs sometimes prepared their foods 4-6hrs before service.

Table 3: Knowledge of Food Safety

Knowledge of Staff Handling Food		TRUE	FALSE	DON'T KNOW
1.	Cold ready-to-eat food should be conserved at 40°c	45	08	47
2.	Bacteria multiply at approximately 90°c	50	02	48
3.	Contaminated food always have change in colour and odour	72	19	09
4.	Germs/microorganisms are in the skin, mouth, nose, of healthy food	80	15	05
Service staff				
1.	Clean is the same as sanitized	50	26	24
2.	Re-freezing illnesses the frosted. food causes food borne	58	22	20
Food service staff should				
1.	Bath regularly	96	00	04
2.	Wear hair cover/cap when handling food	90	02	08
3.	Wear apron when handling food	88	03	09
4.	Consider hands and arms jewelries as sources of contamination	68	12	20
Food service staff cannot safely handle food				
1.	When they have cold, cough and catarrh	79	17	04
2.	When sick with diarrhea even if hands are washed after trip to toilet	77	15	08
3.	When they have an open wound in the hands	83	02	15
4.	When an open wound in the hands is fully bandaged	43	40	17

DISCUSSION

The result shows that most of the foods produce in most of the ready to eat food vendors were contaminated with mostly bacteria. This could be from the raw materials and the sanitary conditions of the environment which the food were processed. Microorganism live throughout the kitchen and can easily move around by attaching themselves to people, food and equipment. Bacteria may pass from equipment to food which are not properly clean or from food to equipment when not properly sanitized before used. Most of the food contamination are from post contamination were due to mishandling of the food after processing before consumption. This is in agreement with the assertions of

Abdullah and Ismail, (2005). Contamination arises from personal unhygienic, dirty bench surface, on-kept consumption tools. The most important food safety problem is microbial food-borne illness. All those who handle food, including farmers, food producers, individuals who work in markets and food service establishments, and other food preparations, have a responsibility to keep food as safe as possible. As found out in this report, handling and environmental factors are precursor to food contamination. This is in agreement with the reports of Akintola (2016). To keep food safe, people who prepare food should clean hands, food contact surfaces, and fruits and vegetables; separate raw, cooked, and ready-to-eat foods; cook foods to a safe internal temperature; chill perishable food promptly; and defrost food properly. A good protocol for washing fresh fruits and vegetables includes removing and discarding outer leaves, washing produce under clean running water just before cooking or eating, washing under running potable water, scrubbing with a clean brush or with hands, and drying the fruits or vegetables using a clean disposable towel. Free moisture on produce may promote survival and growth of microbial populations. Therefore, drying the food is critical if the item will not be eaten or cooked right away.

There was a lack of knowledge among the food service staff about the critical temperatures of cold ready to eat foods and temperatures at which bacteria multiply. It is evident that most of the food handlers have a good knowledge of the needs to wash hands after some activities; moreover, this knowledge was translated to practice by the surveyed fast food outlets food handlers. This may be attributed to the fact that water and hand washing or toilet facilities are readily available in most of the food outlets surveyed. This assertions are in agreement with the reports Abdullah and Ismail, (2005) as a major cause of foodborne disease outbreaks among populace in cities also as reported by Rocourt *et al*. (2003). These important hygiene measures practiced by most of all the food service staff surveyed was very encouraging. The hands are the important vehicles for the transfer of organisms from feaces, nose, skin or other sites to food. Epidemiological studies of Salmonella Typhi, non Typhi Salmonellae, Campylobacter and Escherichia coli have demonstrated that these organisms can survive on finger tips and other surfaces for varying periods of time and in some cases after hand washing (King *et al.*, 2020).

CONCLUSION

The study involve the assessment of health safety of foods served by food vendors on the campuses of Kaduna Polytechnic. After the results obtained from study, it could be concluded that consumers in Kaduna Polytechnic are prone to food borne infections and food poisoning by consuming the foods. The result also showed the prevalence of some microorganisms found in the food such as Staphylococci species, Bacillus species, Streptococci species, Yeast species, Mould species and Coliform species. The result of this work has proved valuable information about food hygiene and safety practice in Kaduna polytechnic, the level of food hygiene and safety practices by food handlers is not satisfactory, some of the hygiene aspects need to be emphasized.

RECOMMENDATIONS

The researchers encourage the continuous education and training should strengthen food handlers' knowledge in area which seems to be lacking and also improve the status of their food hygiene knowledge, attitude and practice of food safety. Foods should be freshly prepared daily and ore so, food from these vendors should be subjected to laboratory analysis on a routine check to ensure safety measures are met.

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RESPONSE OF SOYBEANS (*GLYCINE MAX* (L) MERRILL) AS INFLUENCED BY PHOSPHORUS LEVELS

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ABSTRACT

Two field trials were conducted in 2014 and 2015 rainy seasons at the research farm of the National Cereal Research Institute Badeggi, Niger State within the Southern Guinea Savanna Agro ecological zone to test the response of soybean as influence by phosphorus level. The treatments were made up of five phosphorus level of 0, 20, 25, 30 and 35 kg/ha and were laid out in Randomized Complete Block Design (RCBD) with four replications. Various growth and yield parameters including plant height, number of leave plant, number of branches plant, leaf area plant, fresh pod yield plant^{-1} and fresh pod yield/ha^{-1}. Data collected were subjected to analysis of Variance (ANOVA) using GENSTAT statistical software (17th edition). Treatment means were compared using the least significant difference (LSD) at 5% level of probability. Result revealed that soybeans responded positively to phosphorus application. Application of 35kg/ha^{-1} of phosphorus levels produces significantly, higher fresh pod yield plant^{-1} and fresh pod yield/ha^{-1} than the rest of treatments whiles the control treatment had the lowest pod yield ha^{-1}
Keywords: *Soybean, Phosphorus Fertilizer, growth and yield.*

INTRODUCTION

Soybean (*Glycine max*) is an important leguminous crop that has great importance in sub-Saharan Africa. This is because of its high grain nutritional contents with 40% protein and 20% oil (Fokadu *et al.,* 2009); that make it an economically important crop for human and animal consumption. Soybean is also very important crop for rotation with cereals like maize and sorghum; because of biological nitrogen fixation that is important in improving soil fertility. Also, the plant is considered as a strategic crop in fighting world's food shortage and malnutrition problems (Thomas, 2004). It has been reported that food aids to displaced persons, malnourished people and HIV/AIDS patients are fortified with soybean derivatives (Thomas, 2004).

Despite the wide range of benefit that soybean could provide to subsistence farmer of sub-Saharan African, its productivity is very low (<2.0 t/ha^{-1}) in many of these countries as compared to more than 2.7 t/ha^{-1}productivity obtained in some developed countries (FAO, 2013). Among the several production constraints responsible for the low productivity of soybean especially in many humid tropical regions are soil acidity and its associated poor soil fertility (Staton, 2012). This is common when the soil pH drops below 5.0. Soybean performs well between the pH range of 6.0 and 7.0 with the optimum pH range of 6.3 and 6.5 for maximum performance, nutrient availability and nitrogen fixation (Jandong *et al.*, 2011). The effect of soil acidity on crop production arises from a combination of several factors, notably Aluminum (AL) toxicity which results from large dissolution of aluminum from clay minerals releasing AL^{3+} into soil solution which is the most important rhizotoxic form of the element (Hockenga *et al.,* 2003). Soybean has been reported to absorbed P fertilizers differently in alkaline soil depending on the pH, soil fertility and the nature of genotype (Fatima and choudhary, 2007). To improve crop production in acidic soils, liming has been used to ameliorate the problem of aluminum toxicity. However, liming the top soil remains a temporary solution due to the subsoil acidity. It has been reported that imbalanced and inadequate nutrition results in poor yield of soybean (Lamptey *et al.,* 2008). Due to fixation of applied P in alkali soils, higher doses of the nutrient are required to satisfy the fixation needs and the requirement of the crop (Lamptey e*t al.,* 2008). The alkali soils are generally poor in fertility and require optimum dose of nutrients for higher productivity (Olowoake, 2022). In many agriculture production systems, phosphorus has been identified as the most efficient essential nutrient after nitrogen (Lamptey *et al*., 2008).

The calcareous soil is wide spread throughout the world, thus the availability of phosphorus in these soil is low due to the high calcium carbonate ($CaCO_3$) content which led to chemical fixation of phosphorous (Elkoca *et al.*, 2010) Therefore objectives of this trial is to determine the effect of phosphorus fertilizer level on growth and yield of soybean.

MATERIALS AND METHODS

The experiment was conducted during 2014 and 2015 rainy season at the Research Farm of the National Cereal Research Institute Badeggi, Niger State within the Southern Guinea Savanna Agro ecological zone of Nigeria ($19^0 45^1$ and $7^0 31^1$). Soil samples were collected at the depth of 0-30cm at the research farm before sowing and the soil samples were analysis for physical and chemical properties following the procedure outlined by Olowoake, 2014). The plot size was 45m ×25m which was cleared and prepared manually. The experiment site was divided into 35 plots. Weeding was carried out at regular interval. The treatment consists of five levels of phosphorus fertilizer (*0, 20, 25, 30 and 35*kg/ha^{-1}) application. The design of the experiment was randomized complete block design and replicated four times. Seeds of Soybean were sown at two seeds per hole. The seed variety used was sources from National Seed Council Abuja and the variety used was TGX 1448-2E.

Data were collected on growth and yield of soybean. The height of five randomly selected plant were measure using meter ruler from the ground level to the tip of the upper most leaf and the average was recorded plant^{-1}. The leaves and branches of five randomly selected crops were counted and the average was recorded plants^{-1}. The length and width of five leaves were randomly selected from five plant were measure and multiplied with 2.325 constant proposed by Osei-yeboah *et al* (1983) to obtain leaf area and the average was recorded. Number of fresh pods was obtained by plucking all the pods of five randomly selected plants and average was recorded plant^{-1}. The harvested fresh pods were converted to hectare by multiplying with number of plant ha^{-1}

Statistical Analysis

All data collected were subjected to analysis of variance (ANOVA) using GENSTAT statistical software (17th edition). Treatment means were compared using the least significant difference (LDS) at 5% level of probability.

RESULTS

Table 1 shows the physical and chemical analysis of the soil used for the trial during the 2014 and 2015 rainy seasons. The soil chemical properties was generally low in organic carbon, total nitrogen, also low in phosphorus level. The electrical conductivity (EC) value of the soil (0.08 and 0.09 ds/m^2) indicated that the soils were not salt affected. From the result (Table1) the soil textural class at the experimental site was sandy loam. The soil was slightly acidic tending to alkaline (5.40 to 6.0) condition in water indicating moderate soil condition for crop production (Kamprath, 2009).

Table 1: Physico-Chemical Properties of Soils from 0-30cm at Experimental Site Badeggi, Niger State. During 2014 and 2015 Rainy Season

Soil properties	2014	2015
Particle size (g/kg)		
Clay	130	100
Silt	150	140
Sand	720	750
Textural class	Sandy Loam	Sandy loam
Chemical properties		
P^H (H_2O;1:2:5w/v)	5.40	6.10
P^H (0.01M $CaCL_2$; 2.5w/v)	6.20	6.60
Exchange Acidity (C mol/kg soil)	0.05	0.06
Electrical conductivity (mg/kg)	0.08	0.09
Bray/P (mg/kg)	6.40	7.55
Organic Carbon (g/kg)	4.10	7.55
Total N(g/kg)	0.18	0.31
Exchangeable Cations (Cmol/kg)		
K (Cmol/kg)	0.17	0.25
Ca (Cmol/kg)	4.15	5.25
Mg (Cmol/kg)	0.45	0.91
Na (cmol/kg)	0.23	0.29

CEC K(coml/kg)	5.65	6.75
Extract Micro Nutrients (Cmols/kg		
Zinc (Zn)	0.05	0.07
Sodium Adsorption Ratio (SAR)	6.15	6.55
Percent Base Saturation (PBS)	84.20	88.60

Source: Soil samples as analyzed at the Soil Department, Federal University of Technology (FUT), Minna Nigeria.

Plant Height (cm)

Table 2 shows the effect of phosphorus fertilizer levels on the performance of soybean in 2014 and 2015 rainy season on plant height. There was a significant different ($p<0.05$) among the treatment means due to phosphorus fertilizer levels on plant height. The highest plant height of 39.71cm, 48.36cm was obtain from the phosphorous levels at 35kg ha^{-1} in 2014 and 2015 cropping season. The lowest plant height was recorded (22.33cm), 30.66cm at control where there was no application of phosphorus level in 2014 and 2015 cropping season.

Number of Leaves Plant^{-1}

Table 2 shows response of soybean as influenced by phosphorus fertilizer levels in 2014 and 2015 rainy seasons on number of leaves $plant^{-1}$. This was a significant different ($p< 0.05$) among the treatment means due to phosphorus fertilizer levels on number of leaves $plant^{-1}$ of soybean. The 35kg ha^{-1}recorded highest value of 35.36 and 39.35 in 2014 and 2015 cropping seasons whereas the control had the least value of 21.14cm and 25.29cm in 2014 and 2015 cropping seasons.

Number of Branches Plant^{-1}

Table 2 shows the response of soybean as influenced by phosphorus fertilizer level in 2014 and 2015 rainy seasons on number of branches $plant^{-1}$. There was no significant difference ($p<0.05$) among the treatment means due to phosphorus fertilizer levels on number of branches $plant^{-1}$ of soybean.

Table 2: Effect of Phosphorus Levels on Growth Parameters of Soybean in Badeggi, Niger State.

Treatment	Plant height (cm)		Number of leaves $plant^{-1}$		Number of branches $plant^{-1}$	
Phosphorus rate (kg ha^{-1})	2014	2015	2014	2015	2014	2015
0	22.33 e	30.66 e	21.14 e	25.29 e	14.17 a	16.24a
20	29.38 d	33.38 d	24.35 d	28.28 d	15.33 a	17.37a
25	32.40 c	37.42 c	28.29 c	32.36 c	17.48 a	18.44a
30	36.41 b	41.29 b	31.40 b	36.54 b	19.58 a	20.46a
35	39.71 a	48.36 a	35.36 a	39.35 a	21.28 a	22.48a
SE ±	3.48	3.52	3.32	3.46	3.41	3.50

Means followed by the same letter (s) in a column are not significantly different according to Duncan's Multiple Range Test at 5% levels of probability.

Leaf Area (cm^2) Plant^{-1}

Table 3 shows the response of soybean as influenced by phosphorus fertilizer level in 2014 and 2015 rainy seasons on leaf area $plant^{-1}$. The highest leaf area was recorded at 80kg ha^{-1}phosphorus fertilizer level (43.46), (48.56) in 2014 and 2015 cropping season and the least value was obtained in control plot.

Fresh Pod Yield (g) plant^{-1}

Table 3 also shows the response of soybean as influenced by phosphorus fertilizer levels in 2014 and 2015 rainy season on fresh pod yield $plant^{-1}$. There was a significant difference ($p<0.05$) among the treatment means due to phosphorus combination levels on fresh total shoot yield of soybean. Phosphorus fertilizer level at 35kg ha^{-1}

significantly produced higher mean value over the rest of the treatment, which was followed by 30kg ha^{-1}, followed by 25kg ha^{-1}, followed by 20kg ha^{-1}, and 0kg ha^{-1} which gave the lowest mean value among the treatment.

Table 3: Effect of Phosphorus Levels on Growth Parameters of Soybean in Badeggi, Niger State

Treatment	Leaf area (cm^2)		Fresh pod yield (gm) plant^{-1}		Fresh pod yield (kg) ha^{-1}	
	2014	2015	2014	2015	2014	2015
Phosphorus rate rates (kg ha^{-1})						
0	35.37a	36.34a	43.87e	49.23e	461.37c	570.73c
20	37.53a	38.43a	49.86d	55.86d	573.13c	663.42c
25	39.55	44.36a	55.23c	58.48c	665.25c	779.54c
30	41.33	46.66a	57.22b	61.38b	783.36b	864.63b
35	43.46a	48.56a	59.40a	65.35a	89.72a	970.75a
SE±	3.65	3.68	3.56	3.83	24.44	34.87

Means followed by the same letter (s) in a column are not significantly different according to Duncan's Multiple Range Test at 5% levels of probability.

Fresh Pod Yield (kg) ha^{-1}

Table 3 shows the response of soybean as influenced by phosphorus fertilizer level in 2014 and 2015 rainy seasons on fresh pod yield kg/ha^{-1}. There was a significant difference ($p>0.05$) among the treatment means due to phosphorus combination levels on fresh total yield ha^{-1} of soybean. Phosphorus fertilizer levels at 35kg ha^{-1}significantly produced higher means values over the rest of the treatments which was followed by 30kg ha^{-1}, followed by 25kg ha^{-1}, followed by 20kg ha^{-1}. The least mean values were obtained at 0kg ha^{-1} which was the control plot.

DISCUSSION

Phosphorus application in soybean recorded a significant variation due to varying levels. The soil phosphorus was low but increased significantly with the application of P. phosphorus application increased dry matter accumulation which consequently resulted into translocation of growth and yield traits Mustafa *et al.,* (2004). The increase in phosphorus content in soybean might be attributed to increase in growth resulting into increases in the capacity of plant roots to absorb more of the relatively less mobile phosphorus. This observation is similar to Malik *et al.*, (2006), who observed that application of phosphorus fertilizer up to 70kg P ha^{-1} or more; double the yield of soybean compared with plots testing low in P and with-out P application. This indicate the essentiality of P in soybean mineral nutrition. Chiezey *et al.,* (2013) reported that depending on the nature or fertility stature of the soil, phosphorus is very important and help in mobilization of soil phosphorus which help in plant growth and yield. The entire fresh pod yield improved significantly with P application Malik *et al.,* (2006) reported that plant height is a genetic trait but balance nutrition shows positive effect. Mustafa *et al.,* (2004) reported that P application significantly increased the phosphorus content in soybean shoot yield at harvest. Muhammad *et al.,* (2004) observed that increases in phosphorus content with higher levels help in mobilization of soil phosphorus into available form as a result of action of acid produced by the soil added phosphorus.

CONCLUSION

Application of 35kg ha^{-1} of phosphorus level produced significantly higher fresh pod yield plant^{-1} and fresh pod yield ha^{-1} than the rest of the treatment, while the control treatment produced significantly lower similar traits. Farmers who are into soybean production in Badeggi, Niger State in the Southern Guinea Savannah Agro-ecological zone of Nigeria are advised to used 35kg ha^{-1} of phosphorus levels because it produced significantly higher fresh pod yield plant^{-1} and fresh pod yield ha^{-1} than the other treatments.

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COMPARATIVE STUDY ON THE PHYTOCHEMICAL AND NUTRIENT COMPOSITION OF DIFFERENT PLANT PARTS OF UZIZA (*PIPER GUINEENSE* SCHUM) PLANT

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ABSTRACT

Piper guineense seeds, leaves and stems are among the plant parts commonly used as spices and herbs in medicine. This work was carried out to highlight some proximate, phytochemical and minerals composition in the leaves, seeds and the stems of Piper guineense. The healthy parts were selected, air-dried and pulverized for analysis. Result from phytochemical analysis showed that the highest alkaloid content was recorded in Uziza leaves (0.86mg/100g) and stem (0.42mg/100g). Uziza seed had the highest flavonoid content (1.58mg/100g). The highest phenol content was recorded in Uziza stem (0.34mg/100g). The result from mineral composition showed that the highest calcium content was obtained from the leaves (45.02mg/100g), and stem (21.58mg/100g). The highest potassium content was obtained from the stem (10.72mg/100g). While the seed gave the highest sodium content (19.27mg/100g). The stem had the highest zinc content (0.92mg/100g). The results from proximate composition analysis showed that highest ash content was obtained from the leaves (9.19%). The highest crude fiber was recorded in Uziza stem (12.25%). The highest carbohydrate content was obtained from the seed (71.60%), while the highest crude protein content was obtained from the leaves (12.11%). Pearson Correlation result of the phytochemical composition showed that phenol had strong negative and significant correlation with Saponins ($r = -0.829^{**}$) and Flavonoids ($r = -0.716^{*}$). Phenol also had strong positive and significant correlation with Tannins ($r = 0.904^{**}$). Negative and significant correlation was observed between flavonoids and Alkaloids ($r = -0.846^{**}$) and Tannins ($r = -0.932^{**}$).
Keywords: *Piper guineense, phytochemical, anti-nutrients, spice, Uziza*

INTRODUCTION

Piper guineense herb is a West African spice plant commonly called ashanti pepper (Okoye and Ebeledike, 2013), u*ziza* in Igbo and Iyere in Yoruba. The plant is semi-cultivated in Nigeria, where it is found commonly in the southern part (Okwu 2001). It is used as spice for flavoring, seasoning and imparting aroma to food. They can be consumed as vegetable in human meals but have largely become forgotten foods in the modern westernized diet (Craig, 1999). One of the benefits of uziza is primarily due to its antioxidant properties. Free radicals generated by the body cause damage in living system resulting in oxidative stress (Alobi *et al*., 2012). Free radical scavengers (antioxidants) which are in uziza herbs have potentials to prevent many of human chronic and ageing diseases such as cancer, diabetes, heart disease, stroke, malaria, and rheumatoid arthritis (Agbaire, 2011). The seeds are consumed by women after childbirth to enhance uterine contraction for the expulsion of placenta and other remains from the womb (Mbongue *et al.,* 2005), as an anti-asthmatic and to control weight (Morebise *et al*., 2002). These plants are as important today as they were in ancient times for enhancing the flavor and taste of our foods. So many people consume vegetables because of their flavors and taste, and do not concern themselves with their nutritional composition. Ignorance concerning the nutritional properties of different plant parts and presence of some phytochemicals are the major reasons for underutilization of these plant. Therefore, the research findings from this work will enlighten the consumers on the phytochemical and nutrients composition of different plant parts of Uziza plant. The objective of this study is therefore; to compare the phytochemical and nutrients composition of different plant parts of uziza and to examine the relationship between the proximate composition and the phytochemical composition of some Uziza consumed in Nigerian.

MATERIALS AND METHODS

The fresh samples of the leaves, stems and seeds of *Piper guineense* (Uziza) were collected from Obuohia Ibere village in Ikwuano Local Government Area of Abia State, Nigeria. Phenolic compounds were determined by an HPLC method using an Agilent 1100 Series liquid chromatograph (USA) equipped with a UV/DAD detector. Determination of Saponins was done by the double solvent extraction gravimetric method (AOAC, 2005). $\% \, Saponin = \frac{W_2 - W_1}{W}$, Where W = Weight of sample used, W_1= Weight of empty evaporation dish, W_2 = Weight of dish + saponin extract. The tannin contents were determined using Folin Denis Reagent as described by Inyang and Emosairue, (2005). Calcium was determined using the method described by Pearson (1976). Ca (mg/1) = $\frac{T \, x \, M \, x \, E \, x \, 100}{Volume \, of \, sample \, use}$, Where., T = titer value, M = Morality of EDTA, E = Equivalent weight of calcium. The carbohydrates were determined by difference according to Oyenuga (1968) as follows; % Carbohydrates = 100 – (% moisture + % fat + % ash + % protein +% crude fiber). Crude protein was determined using the Kjeldahl method (Adeyeye, 2017). Statistical analysis; Data collected from this study was subjected to Analysis of Variance (ANOVA) test, using Genstat 12 software. Means was separated using least significant different (LSD) at 5% significant level. Pearson Correlation Coefficient used to estimate the linear relationships between the minerals and the phytochemical composition of the plant (Ofori, 1996) was computed using Statistical Package for Social Sciences (SPSS) for windows 2012 version, 21.0.

RESULTS

Phytochemical composition

Result from ANOVA showed that all the traits were highly significant ($P<0.01$). The result from the figure 1 showed that the highest alkaloid content was recorded in Uziza leaves with the value of 0.86mg/100g. This was followed by Uziza stem that had alkaloid content of 0.42mg/100g. Least alkaloid content was obtained from the Uziza seed (0.27mg/100g). However, the highest flavonoid content was recorded in Uziza seed (1.58mg/100g), followed by Uziza stem that had flavonoid content of 0.96mg/100g. Least content of flavonoid was obtained from the leaves (0.76mg/100g) (Fig. 1). The highest phenol content was recorded in the stem (0.34mg/100g). This was followed by the leave that had phenol content of 0.23mg/100g. Least content was obtained from the seed (0.12mg/100g). Similarly, the highest saponin was recorded in Uziza seed with the value of 2.61mg/100g. However, the stem recorded saponin content of 1.39mg/100g. Least saponin was obtained from the leaves (1.32mg/100g). The highest tannin content was recorded in Uziza stem (1.44mg/100g). This was followed by Uziza leaves that had tannin content of 1.28mg/100g (Fig. 1).

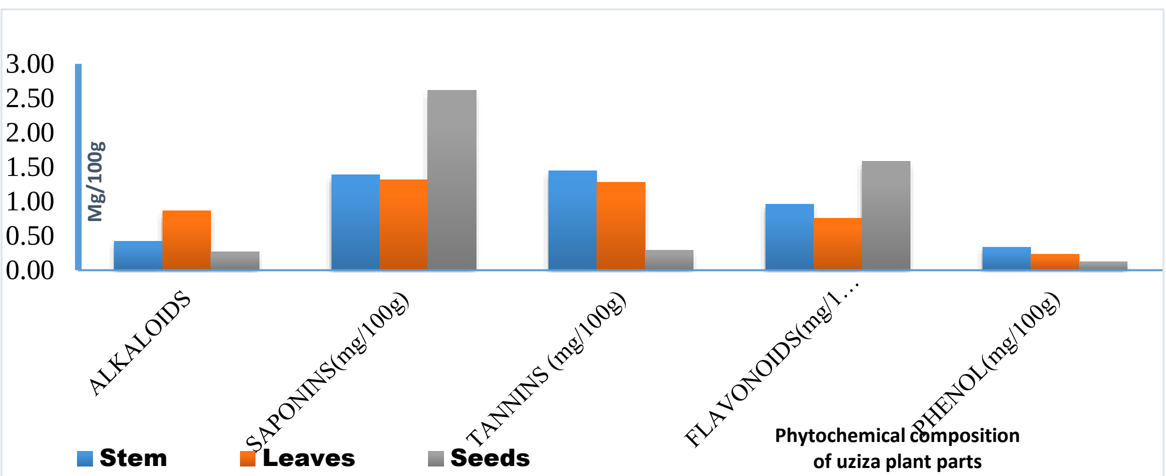
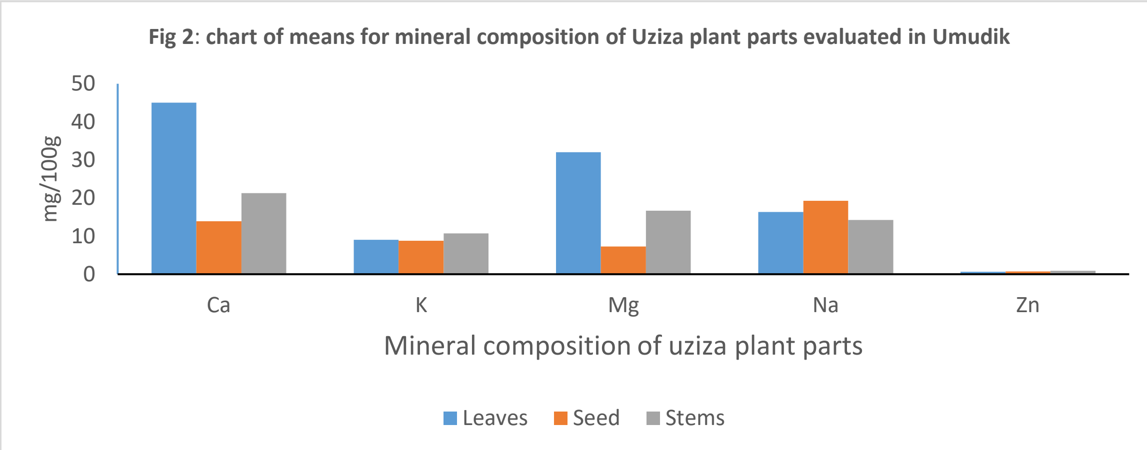


Figure 1: Bar chart of means for phytochemical contents of Uziza plant parts evaluated in Umudike

Mineral composition

The mean results showed that the highest calcium content was obtained from the leaves with the value of 45.02mg/100g, followed by stem (21.58mg/100g) and seed (13.87mg/100g). The highest potassium content was obtained from the stem (10.72mg/100g), followed by leaves (9.02mg/100g) and seed (8.80mg/100g). Also the highest magnesium content was obtained from the leaves with the value of 32.07mg/100g. This was followed by stem (16.67mg/100g) and seed (7.24mg/100g). While the highest sodium was obtained from the seed (19.27mg/100g), followed by leaves (16.34mg/100g) and stem (14.21mg/100g). With respect to zinc, the highest content was obtained from the stem with the value of 0.92mg/100g. This was followed by seed (0.73mg/100g) and leave (0.63mg/100g) (Fig. 1).



Proximate composition

Figure 3 presents the proximate composition of Uziza plant parts. Mean results showed that the highest ash content was obtained from the leaves with the value of 9.19%. This was followed by seed (5.69%) and stem (2.91%). The highest crude fiber content was recorded in the stem (12.25%), followed by the leave (10.30%) and the seed (3.46%). The highest carbohydrate content was obtained from the seed with the value of 71.60%. This was followed by stem (69.29%) and leave (57.22%), while the highest crude protein content was obtained from the leaves (12.11%). This was followed by seed (6.89%) and stem (2.74%). However, the highest ether extract content was obtained from the seed (3.61%), followed by the leaves (2.93%) and stem (1.38%). While the highest energy value content was obtained from the seed (364.48kcal/100g). This was followed by leaves (303.74kcal/100g) and stem (300.50kcal/100g). The highest moisture content was obtained from the seed (9.41%), followed by stem (9.28%) and leave (8.91%). Piper guineense stem, seed, and leaf phytochemical analysis provides a good dietary complement and also provides a significant quantity of anti-nutrient alkaloids, tannins, and spaonins that may also offer some health benefits to its consumers. These compounds may also help consumers consume less starchy meals, improve nourishment and protection, and avoid constipation. Above it all, it is also noted that Uziza leaves are affordable vegetables that can contribute to our nutritious values.

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ORANGE FLESHED SWEET POTATO AS A PANAECEA FOR HIDDEN HUNGER AMONG RURAL HOUSEHOLDS IN EBONYI STATE NIGERIA

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ABSTRACT

This study aims to highlight the significance of orange-fleshed sweet potato as a panacea for hidden hunger among rural households in Ebonyi State, Nigeria. It will discuss the nutritional benefits of OFSP, its adaptability to local agricultural conditions, and the impact it can have on alleviating micronutrient deficiencies in the region. Hidden hunger, characterized by deficiencies in essential micronutrients, remains a critical public health concern among rural households in Ebonyi State, Nigeria. The introduction and promotion of orange-fleshed sweet potato in Ebonyi State can significantly contribute to reducing hidden hunger among rural households. By incorporating OFSP into their diets, communities can improve their overall nutritional intake and prevent micronutrient deficiencies. The cultivation and consumption of OFSP may lead to enhanced health outcomes, particularly for vulnerable groups such as pregnant women and young children, positively impacting their growth and development. Additionally, the study highlighted the socio-economic and cultural factors influencing OFSP adoption. Findings suggest that promoting OFSP cultivation and consumption holds great promise in combating hidden hunger, enhancing food security, and improving overall nutritional well-being in rural communities of Ebonyi State, Nigeria. This research contributes vital insights for policymakers and stakeholders seeking effective strategies to combat hidden hunger and promote sustainable nutrition security

Keywords: *Orange Fleshed Sweet potato, panacea, Hidden hunger and rural households*

INTRODUCTION

Hidden hunger, also known as micronutrient deficiency, remains a significant challenge in many developing regions, including Ebonyi State, Nigeria. It refers to the chronic lack of essential vitamins and minerals, such as iron, zinc, and vitamin A, in the diets of individuals and communities. This nutritional deficiency can have severe consequences, particularly for vulnerable groups like pregnant women, children, and the elderly, leading to impaired physical and cognitive development, increased susceptibility to diseases, and overall reduced quality of life. In recent years, increasing attention has been drawn to orange-fleshed sweet potato (OFSP) due to its potential as a sustainable solution to combat hidden hunger (FAO, 2010). FAO (2020), OFSP is a biofortified variety of sweet potato enriched with beta-carotene, a precursor of vitamin A. Its vibrant orange flesh sets it apart from traditional white or yellow-fleshed sweet potatoes, making it a visually appealing and nutrient-dense option for improving the nutritional status of rural households. Amagloh *et al* (2011) , Omoare (2017) Orange-fleshed sweet potatoes are rich sources of beta-carotene, an essential nutrient that the human body can convert into vitamin A. Vitamin A plays a vital role in maintaining healthy vision, immune function, and cell growth. By incorporating OFSP into their diets, rural households can enhance their vitamin A intake, reducing the risk of vitamin A deficiency-related health issues such as night blindness and increased susceptibility to infections (Omoare, 2015, Njoku, 2007). Ebonyi State's rural communities often face challenges related to agriculture, such as limited access to irrigation, unpredictable weather patterns, and soil degradation. Orange-fleshed sweet potatoes have proven to be resilient and adaptable to a range of agro ecological conditions, making them a viable option for smallholder farmers in the region. Their ability to thrive in less fertile soils and their resistance to certain pests and diseases can contribute to increased crop productivity and food security. In recent years, agricultural research and development organizations, along with governmental and non-governmental partners, have undertaken initiatives to promote the cultivation and consumption of orange-fleshed sweet potato in Ebonyi State. These efforts have sought to raise awareness about the nutritional benefits of OFSP, provide training and support to farmers, and integrate OFSP into school feeding programs to reach vulnerable populations effectively. Overall, the unexpected value of OFSP lies in its ability to tackle hidden hunger by providing an abundant, accessible, and nutritious crop that fits well into existing food systems. It's potential to improve nutrition, livelihoods, and food security has led to widespread adoption and recognition as an essential tool in the fight against hidden hunger (Oyediran *et al* 2017, Low *et al* 2010).

This paper therefore reviewed the potentials of orange-fleshed sweet potato as a panacea for hidden hunger among rural households in Ebonyi State, Nigeria. By examining the nutritional benefits of OFSP, its adaptability to local agricultural conditions, and the impact it can have on alleviating micronutrient deficiencies, this study seeks to advocate for greater adoption and integration of OFSP into rural farming systems and diets.

METHODOLOGY

Secondary data was used to elicit information from textbooks, journals, proceedings, guides bulletins and some national dailies.

RESULTS AND DISCUSSION

Orange Fleshed Sweet Potato as a Panacea for Hidden Hunger Transformation

Hidden hunger (micronutrient deficiency), is a persistent issue affecting vulnerable populations worldwide. It arises from a lack of essential vitamins and minerals in diets, particularly in regions where access to diverse and nutritious foods is limited. One innovative and impactful solution to combat hidden hunger is the promotion and adoption of orange-fleshed sweet potato (OFSP). (Endrias *et al*., 2016)

Nutritional Powerhouse: Orange-fleshed sweet potato is a bio-fortified variety enriched with beta-carotene, a precursor to vitamin A. Its vibrant orange color is indicative of its high nutrient content. By incorporating OFSP into diets, particularly in regions with vitamin A deficiency, individuals can improve their nutritional intake and combat related health issues such as night blindness, weakened immune systems, and increased vulnerability to infections. (Kurabachew, 2015)

Vitamin A Delivery: Vitamin A plays a critical role in various physiological functions, including vision, immune function, and growth. OFSP offers an effective and natural means of delivering vitamin A, ensuring a sustained and accessible supply to communities. This transforms OFSP into a powerful tool for improving health outcomes, especially for pregnant women, young children, and those with compromised immune systems. (Hortz *et al*., 2012)

Agricultural Adaptability: OFSP is renowned for its adaptability to diverse agro ecological conditions, making it suitable for cultivation in regions facing challenging agricultural circumstances. Smallholder farmers can benefit from growing OFSP alongside traditional crops, leading to diversified farming practices and enhanced food security. The ability to grow OFSP in poor soil conditions and with minimal water resources empowers farmers to address hidden hunger within their communities sustainably. (Ejigu *et al*., 2022).

Women and Rural Empowerment: In many regions affected by hidden hunger, women bear the primary responsibility for household nutrition and food preparation. By promoting the cultivation and consumption of OFSP, women can become key drivers of change in addressing micronutrient deficiencies. Additionally, OFSP can serve as an income-generating crop for women, empowering them economically and socially. (Abidin *et a*l., 2015)

Climate Resilience: OFSP's ability to thrive under challenging conditions contributes to climate resilience. As climate change impacts agriculture and food systems, the cultivation of resilient crops like OFSP becomes crucial for securing food and nutrition for vulnerable populations. Furthermore, its potential for carbon sequestration can make it an environmentally sustainable option for farming practices. (Wees *et al*., 2015)

Sustainable Food Systems: By promoting OFSP, communities can transition towards sustainable food systems that prioritize nutrition, biodiversity, and resilience. The integration of OFSP into dietary habits and food value chains fosters a culture of diversified nutrition, reducing reliance on monotonous diets and their associated health risks. (Danlo *et al*., 2023).

Policy and Institutional Support: Transforming hidden hunger through OFSP requires supportive policies and institutional frameworks. Governments, international organizations, and local stakeholders can collaborate to provide necessary infrastructure, resources, and technical assistance to promote OFSP cultivation, processing, and consumption.

Challenges of Orange Fleshed Sweet Potato

Awareness and Acceptance: One of the primary challenges is creating awareness about the benefits of OFSP and encouraging its acceptance among the local population. Many people may be unfamiliar with this crop or may have cultural preferences for other staple foods.

Farming and Production: Scaling up the production and availability of OFSP can be challenging. It requires suitable agricultural practices, proper storage, and distribution mechanisms to ensure a consistent and reliable supply throughout the year.

Knowledge and Training: Farmers need access to training and knowledge on best practices for cultivating, storing, and processing OFSP. Lack of information and expertise can hinder successful cultivation and utilization of the crop.

Infrastructure and Market Access: The success of OFSP as a solution for hidden hunger relies on a functional agricultural infrastructure and market access. If farmers face difficulties in transporting their produce to markets or accessing markets with fair prices, they may not be incentivized to grow OFSP.
Socioeconomic Factors: Poverty and limited access to resources can hinder the adoption of new agricultural practices. Farmers may prioritize crops that offer immediate economic benefits over those that address hidden hunger in the long term.
Post-Harvest Losses: Proper storage and processing of OFSP are crucial to preserving its nutritional content. Post-harvest losses due to lack of appropriate storage facilities and processing techniques can diminish the nutritional impact of the crop.
Dietary Diversity: Although OFSP is rich in vitamin A and other nutrients, it should not replace other essential food groups in the diet. Promoting dietary diversity alongside the inclusion of OFSP is essential to address various nutritional deficiencies.
Climate Change and Pests: Climate change can impact agricultural productivity, affecting the availability and quality of OFSP. Additionally, pests and diseases can cause significant crop losses and reduce yields.
Gender Inequality: Women are often key players in agriculture and nutrition, but they may face barriers to access resources and information, limiting their ability to benefit from the introduction of OFSP.

Way Forward in Addressing Hidden Huger with (OFSP)

Addressing hidden hunger among rural households with orange-fleshed sweet potato (OFSP) involves targeted interventions that focus on promoting the cultivation, consumption, and utilization of this nutritious crop. Here are some specific strategies for the way forward:
Promotion and Awareness Campaigns: Launch targeted awareness campaigns about the nutritional benefits of OFSP, emphasizing its high vitamin A content and potential to address hidden hunger. These campaigns can involve community meetings, radio broadcasts, posters, and workshops to reach rural households effectively.
Capacity Building and Training: Provide training and capacity-building programs to rural farmers on best practices for cultivating, storing, and processing OFSP. This can include techniques for soil management, planting, harvesting, and post-harvest handling to minimize losses and preserve nutritional content.
Seed Distribution and Access: Facilitate access to high-quality OFSP planting materials and ensure their availability in rural areas. This can involve establishing community seed banks and promoting the use of disease-resistant and climate-adapted varieties.
Strengthening Value Chains: support the establishment of OFSP value chains that link rural farmers with markets, processors, and consumers. This can improve income opportunities for farmers and ensure a steady supply of OFSP products to consumers.
Nutritional Education: Implement nutrition education programs that teach rural households about the importance of dietary diversity, including the inclusion of OFSP in their regular meals. Demonstrate how OFSP can be incorporated into traditional recipes to enhance their nutritional value.
Processing and Preservation: Encourage the development and adoption of simple and affordable processing techniques for OFSP, such as drying, milling, and making products like flour, snacks, and porridge. This can extend the shelf life of the crop and increase its availability throughout the year.
Community-Based Interventions: Involve local communities in planning and decision-making processes related to OFSP interventions. Community engagement fosters ownership and sustainability of projects.
Gender Sensitivity: Recognize the role of women in agriculture and nutrition and ensure that interventions address their specific needs and challenges. Women often play a crucial role in food production and preparation, making their involvement essential for successful outcomes.
Monitoring and Evaluation: Establish robust monitoring and evaluation systems to assess the impact of OFSP interventions on hidden hunger and nutrition outcomes among rural households. Regular assessments will help identify areas for improvement and ensure the effectiveness of interventions.
Policy Support: Advocate for policies that promote the cultivation and consumption of OFSP among rural households, including incentives for farmers, subsidies for inputs, and integration of OFSP in school feeding programs.

CONCLUSION

In conclusion, hidden hunger, characterized by micronutrient deficiencies despite sufficient caloric intake, remains a persistent challenge in many regions, particularly in developing countries. Addressing this issue requires a multi-faceted approach involving governments, NGOs, international organizations, communities, and individuals. One unexpected but highly effective solution for hidden hunger is the orange-fleshed sweet potato (OFSP). OFSP stands out as a nutritious and versatile crop due to its high beta-carotene content, which addresses vitamin A deficiency, a widespread health concern. Its cultivation adaptability, climate resilience, and integration into local food systems make it accessible and acceptable to diverse communities. Embracing OFSP presents numerous benefits beyond its nutritional value. It supports sustainable agricultural practices, empowers farmers economically, and promotes health and well-being in vulnerable populations. Additionally, it's simple processing and versatility in various food products makes it a valuable resource year-round. However, to fully utilize OFSP's potential as a solution for hidden hunger, challenges must be addressed, such as awareness and acceptance, access to quality planting materials, capacity building, gender sensitivity, and the strengthening of value chains.

By adopting a holistic approaches, including nutrition education, policy support, and collaboration between stakeholders, we can unlock the unexpected potential of orange-fleshed sweet potato to combat hidden hunger. This nutritious crop not only offers a source of essential nutrients but also represents a pathway towards sustainable agriculture, improved livelihoods, and better health outcomes for vulnerable populations. Embracing OFSP is a step towards a healthier, more resilient, and food-secure future for communities worldwide.

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EVALUATION OF SUSTAINABLE ONION (*ALLIUM CEPA* L.) PRODUCTION IN DADINKOWA GOMBE STATE

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ABSTRACT
*Field experiment was conducted to evaluate the effect of row spacing and variety on the growth and yield of onion during 2021 rainy season at the Teaching and Research Farm of Federal College of Horticulture Dadinkowa in Yamlatu Deba local government area of Gombe state. Three (3) row spacing (30cm x 10cm, 30cm x 15cm and 30cm x 20cm) were used and two (2) onion Varieties (**V1**`Yar Rumi and **V2** Zobo variety) laid in a Randomized complete Block Design in 3 replications of 5 plots each. The plots size was 2m x 2m (4m^2) with 1m space between the replications and 0.5m between plots. Total number of plots was 15. The results of the research showed that 30x20 cm and variety two were the best on plant height, number of leaves, collar girth, leaf fresh weight and bulb diameter but there were no significant differences on number of leaves and bulb diameter between the varieties. It was therefore suggested that farmers in the study area should adopt 30x20cm spacing and Zobo variety for optimum performance.*

INTRODUCTION
The onion (*Allium cepa* L.) is a vegetable crop grown for its pungent bulbs and flavourful leaves. It belongs to the genus *Allium* of the family *Alliaceae* or *Amaryllidaceae* (Welbaum, 2015). Onion is one of the most important vegetable crops commercially grown in the world. It probably originated from Central Asia between Turkmenistan and Afghanistan where some of its relatives still grow in the wild. Onion from Central Asia, the supposed onion ancestor had probably migrated to the Near East (Bagali *et al.*, 2012). The production of the crop in Northern Guinea Savannah is low when compared to the land area under cultivation by Onion farmers in the area. This could be due poor management practices that has high impact on the crop performance especially selection of varieties with laudable performance, Fertilizer application (forms, rates of application, time of application) and spacing which determine the plant population and quantity of inputs needed (seeds, fertilizer, pesticides), key determinants of cost of production. The study was conducted to determine the most suitable spacing for growth and yield of Onion in the study area and to evaluate the performance of the varieties used.

MATERIALS AND METHOD
The Field experiment was conducted during 2021 rainy seasons at the Teaching and Research Farm of Federal College of Horticulture Dadinkowa in Yamlatu Deba local government area of Gombe state to evaluate the impact of management practices on sustainable onion production in the study area. Three (3) intra-row spacing (30cm x 10cm, 30cm x 15cm and 30cm x 20cm) and two (2) onion Varieties (**V1**`Yar Rumi and **V2** Zobo variety) laid in a Randomized complete Block Design in 3 replications of 5 plots each. The plots size was 2m x 2m (4m^2) with 1m space between the replications and 0.5m between plots. Total number of plots was 15.

Data were collected on plant height, number of leaves, collar girth, and leaf fresh weight at two weeks interval and, bulb diameter at harvest from the five randomly selected plants. The Data collected were subjected to Analysis of variance by Genstat software and means were separated using least significant difference at 5% level of probability.

RESULTS
The results on plant height indicated that 30cmx10 cm recorded the highest mean value at 2 and 4WAT even though there was no significant difference at 2WAT a situation that could be attributed to the closer spacing a condition that encourages competition between the onions stands for space and sunlight. But at 6 and 10WAT the highest value was

recorded by 30cmx20 cm spacing which was the widest spacing used in the research, 30x15 cm at 8WAT had the highest record of number of leaves, the results showed that even though there was no significant difference between the three spacing intervals with the exception of 6 and 10WAT where 30x10 cm performed better, highest values were recorded by the wider spacing at 4, 6 and 8WAT.

Results on collar girth revealed that there was no significant difference between the three-row spacing as recorded in the first sampling period but significant differences were recorded in the subsequent data where 30x20 cm recorded the highest values at 4, 6 and 8WAT while 30x15 cm had the highest at 10WAT.

Leaf fresh weight was higher at wider row spacing (30x20cm) a condition that might be as a result of enough space that supports vigorous growth and low population that made the available nutrients enough for the plant to utilize and build their leaves and sufficient moisture that buffered the water content there increasing their weight and results in higher weight values.

The results on Bulb diameter showed that row spacing significantly influences the bulb size where 30cm x20 cm spacing recorded the highest values. This might be due to the due to the wider space that provided avenue for enlargement of the bulb without tightness and more moisture and nutrients that were at the disposal of the widely spaced onions.

Table 1: Effect of Row Spacing and Variety on the Growth and Yield of Onion (*Allium cepa* L.) in Dadinkowa Gombe State

Treatments	PH	NL	CG	LFW	BD
	63.54	10.99	5.47	43.02	39.42
	64.73	10.91	5.76	44.79	38.60
	65.23	10.91	6.25	45.05	39.68
	*	NS	**	**	**
	1.142	0.1915	0.2003	0.2443	0.3714
	63.19	10.94	5.73	43.94	39.28
	65.81	10.93	5.92	44.63	39.18
	**	NS	**	**	NS
	0.729	0.1363	0.1169	0.2982	0.1634

KEY: PH=plant height, NL=number of Leaves, CG=collar girth, LFW=leaf fresh weight, BD=bulb diameter.

The results on plant height displayed significant variation between these varieties with the exception of first sampling period and, V2 (*Zobo*) recorded the highest values throughout the sampling period. The result on number of leaves showed that no significant differences were observed throughout the sampling period. The results on collar girth showed that *Zobo* (V2) recorded the largest values during the sampling periods. Leaf Fresh weight the result shows significant variation in the performance of the two varieties with regard to fresh weight where *Zobo* (V2) recorded the highest value.

DISCUSSION

This result conformed to the findings (Latif *et al*., 2010) who indicated that the numbers of leaves per plant, bulb weight, foliage dry weight, plant height was highest when the plants were grown at wider spacing of 20cm x 20 cm. There was no marked difference even at period during which the closest spacing had the highest values and this showed that still wider spacing produces highest number of leaves as reported by (Sikder *et al*., 2010); (Latif *et al*., 2010 and Ehizogie *et al*., 2015). This showed that wider spacing provide avenue for enlargement of the onion neck which is also related to the bulb size because of adequate space encourages widening in size in addition to nutrients and moisture availability. This result agreed with the findings of (Brewster, 2010); (Guesh, 2015) who reported that in order to produce large bulbs (>70 mm in diameter) a plant population of between 25 and 50 plants m^2 is required, for medium bulbs (25-50 mm) between 50 and 100 plants m^2 and for small bulbs (<50 mm) more than 100 plants m^2 are required.

This result shows that the Leaf fresh weight was higher at wider row spacing (30x20cm) a condition that might be as a result of enough space that supports vigorous growth and low population and was in agreement with the findings of (Jilani *et al.*, 2010); Sikder *et al*., 2010); Latif *et al*. (2010) and Ehizogie *et al*. (2015) who reported that wider spacing supports growth parameters of onion.

This results conformed to the findings of (Jilani *et al.*, 2010) who stated that although the widest plant spacing (25 cm) produced the maximum leaves per plant, plant height, bulb weight and bulb diameter, but it reduced the yield per plot and total yield.
The result of V2 recorded the highest values was in conformity with the findings of Chala *et al.* (2022) who reported that Plant height was very important ($P < 0.01$) affected by the significant effect of NPS fertilizer levels, varieties and significantly ($P \leq 0.05$) its interaction. The number of leaves shows no significant, this might be due to similarity of the varieties genetically even though it contradicted the findings of Nasha *et al*. (2018) who in his study reported that variety V3 (Agrifound Light Red) recorded a higher mean value of number of leaves per plant than the variety V2 (NHRDF Red-3) at different stages of growth. Varity V1 (NHRDF Red-1) recorded minimum number of leaves at all the stages of the crop growth.
The results shows that V2 recorded the highest collar girth during the throughtout the observation, (Nasha *et al*., 2018) whose research data indicated significant effect of varieties on neck thickness of bulb at harvesting stage. The result shows that the leaf fresh weight was significant and this result was in agreement with the findings of Paul *et al.* (2017) reported that the highest onion fresh weight of 37.15 g was recorded at treatment A3, followed by A2 of 33.18 g, A2 of 29.01 g and A0 of 22.41 g. Results on bulb diameter revealed no significant difference between the two varieties and this might be due genetic makeup of the varieties and the management practices employed. This results contradicted the findings of Nasha *et al*. (2018) Varieties also had significant effect on polar diameter of bulb.

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ASSESSMENT OF COLOUR ATTRIBUTES OF SOME SELECTED YAM CLONES USING INSTRUMENTAL METHOD

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ABSTRACT
This study evaluated the colour intensities of some selected yam varieties using a high throughput Chromameter. The results showed significant differences in the colour intensities of the fresh yam samples evaluated. The L value, which was used to measure lightness or whiteness of the fresh yam samples ranged from 69.993 nm in the head section of sample 11/00873 to 81.225 nm in the middle section of the same tuber while a* value, which measured the red to green pigments ranged from -1.760 nm (Tail section of sample 11/00582) to 2.480 nm (Head section of TDA 291). Values of b* (measure of yellow to blue colour ranges) ranged from 13.955nm in the middle section of sample TDA 291 to 25.643 nm in the head section of 89/02665. The study showed that high-throughput chromameter can be used to assess the colour intensities of fresh yam.*
Keywords: *Colour Intensity, Yam, Chromameter*

INTRODUCTION
Yam, a common name used to describe crops belonging to the genus *Dioscorea* is an annual crop, which belongs to a major staple food crop grown in tropics and sub-tropics for its tubers (Alabi *et al*., 2019). There are many species of yam with different flesh colors, which varies from white to red (Leng *et al*., 2016). However, white yam and yellow yam (*Dioscorea rotundata* and *D. cayenensis*) are the most important and are native to Africa. Yams are consumed in different forms such as boiled, roasted, fried, pounded or processed into flour for other uses (Honfozo *et al*., 2020). However, they undergo colour changes during processing as a result of enzymatic browning by the action of polyphenoloxidase. The colour of yam is measured in intensity and wavelengths depending on the pigments, which may be fat-soluble chlorophylls (green), carotenoids (yellow, orange, and red), water-soluble anthocyanins (red, blue), flavonoids (yellow) or betalains (red) (Barrett *et al*. ,2010). Studies have shown that subjective methods have been used in determination of colors of yam using qualitative descriptive analysis, however, this method does not give the true representation of the yam colours despite the rigors involved in carrying out the evaluation. Colour attribute is important in the consumer acceptance of food (Johannes and Borquez, 2014) and color of food could be determined by their L*, a* and b* values (L* used to measure the lightness of the yam, a* values used to represent the red to green color range and b* values for representing the yellow to blue color range) using Chromameter. It uses a sensor that mimics the function of human eye in sensing colours which are quantified after measuring the three primary colors, which are red, green, and blue in the food (Phatare *et al*, 2013). This method is easier and faster. Therefore, this study aims at evaluating the colour intensities of some selected yam varieties using high throughput Chromameter.

MATERIALS AND METHODS
Fresh 4 African yam varieties harvested from Ezza-mgbo in Ebonyi state were peeled, washed and sliced to 2mm thickness with clean knives. A colorimeter (Konica Minolta CM-3700; Japan) was used to evaluate the colours of the boiled yam sections as well as the fresh-cut yam slices. *L**, *a**, and *b** values at 3 sites on each of the 6 yam slices were measured and their different colour intensities measured. Data generated were expressed as three replications and were subjected to one-way analysis of variance (ANOVA). P values ≤ 0.05 were regarded as significant. All the statistical analysis were performed with SPSS software (version 20).

RESULTS AND DISCUSSION
Table 1 shows the colour intensities of the yam samples.There were significant ($p<0.05$) differences in the colour intensities of the fresh yam samples evaluated. The L* is used to measure the lightness of the yam color (Homaida

and Yang, 2017) in the range of 0−100, where zero represents the darkest (or blackness) and 100, for the whitest color. The L* values ranged from 69.993nm in the head section of sample 11/00873 to 81.225nm in the middle section of the same tuber. Samples with high L* value indicate high brightness. This implies that the middle section of sample 11/00873 was very white in colour while the head section with the lowest L* value had the darkest colour among the yam samples evaluated. The a* values are used to represent the red to green range were red colors have positive values and green colors have negative values. The results obtained showed that a* ranged from -1.760 nm (Tail section of sample 11/00582) to 2.480nm (Head section of TDA 291). Samples with higher positive values of a* showed that they have more red pigments than samples observed in the head section of TDA. All the other sections of the other varieties had negative values indicating the presence of green pigments in the tubers with the tail section of sample 11/00582 having the highest green pigment among all the samples assessed.
The b* values are used to represent the yellow to blue color range where the positive values represent the yellow color and the negative values represent blue colours. Values of b* ranged from 13.955 nm in the middle section of sample TDA 291 to 25.643nm in the head section of 89/02665. This shows that the middle section of the fresh yam sample from TDA 291 had more yellow pigments in its tuber than the other samples evaluated while the head section of 89/02665 tended towards blue colour. The results showed that among the samples evaluated, the middle section of sample 11/00873 and the middle section of sample TDA 291 had brighter colours. This implies that consumers and processors that want to obtain brighter end product such as pounded, boiled yam, yam flour among others should choose from these genotypes that contained few dark pigments in them as it is easy to predict the color quality of their end products from the raw material .

Table 1: Colour intensities of the different sections of fresh yam

GENOTYPE	L*	a*	B*
89/02665			
H	80.093^{ab}	-0.415^{b}	25.643^{a}
M	80.030^{ab}	-1.205^{bcd}	21.625^{b}
T	76.990^{dd}	-0.785^{ab}	18.865^{cd}
11/00873			
H	69.993^{e}	-0.423^{b}	18.973^{cd}
M	81.225^{a}	-1.015^{bcd}	18.365^{cd}
T	80.095^{ab}	-1.225^{bcd}	19.485^{c}
11/00582			
H	76.903^{cd}	-0.785^{ab}	18.930^{cd}
M	79.723^{abc}	-1.458^{cd}	17.943^{d}
T	77.385^{bcd}	-1.760^{d}	18.275^{cd}
TDA 291			
H	75.956^{d}	2.480^{a}	16.470^{e}
M	78.533^{bcd}	-0.790^{ab}	13.955^{f}
T	76.688^{d}	-1.140^{bcd}	16.103^{e}

Means with the same superscripts in the same column are not significantly different (P>0.05)
L* = measurement of lightness of yam
a* = values used to represent the red to green color range
b* = values representing the yellow to blue color range

CONCLUSION

The study showed that the different colour intensities of yam genotype could be assessed using a high throughput chromameter, which is easier and faster than the QDA (qualitative descriptive analysis), which is subjective, time consuming and not economical; although, this was used in this study. Breeders can leverage on this study to put more efforts in breeding genotypes that meet end-users preferences.

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