FEDERAL UNIVERSITY OF AGRICULTURE, ABEOKUTA

PROCEEDINGS

OF THE

PROCEEDINGS OF THE 2 ND BIENNIAL CONFERENCE OF THE COLLEGE OF PLANT SCIENCE AND CROP PRODUCTION

THEME:

ADVANCING SUSTAINABLE FOOD SYSTEM THROUGH CLIMATE – SMART CROP PRODUCTION

DATE:

SUNDAY 20TH – THURSDAY 23RD JULY, 2025

VENUE:

INTERNATIONAL SCHOLAR CENTRE,

CENTRE OF EXCELLENCE IN AGRICULTURAL DEVELOPMENT AND SUSTAINABLE ENVIRONMENT (CEADESE),

FEDERAL UNIVERSITY OF AGRICULTURE, ABEOKUTA (FUNAAB), OGUN STATE

ISBN: ……………..
Published by the University Library Printing Press, Federal University of Agriculture, Abeokuta, Nigeria

Compiled by:
Prof. Adeniyi A. Soretire
Prof. Olusegun. A. Oduwaye
Prof. O. R. Adeyemi
Dr. Nurudeen. O. Adeyemi
Mr. Olasupo J. Fadeyi

This book contains the edited and unedited abstracts/manuscripts of all special talks, invited talks and oral presentations at the Gnetics Society of Nigeria 45th Annual Conference held form 26th – 30th of March, 2023 at the International Scholar Centre, Centre of Excellence in Agricultural Development and Sustainable Environment (CEADESE), Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, Nigeria.

Organizers are not responsible for the accuracy of the content of this book.

2ND
BIENNIAL CONFERENCE
COLLEGE OF PLANT SCIENCE AND CROP PRODUCTION
COLPLANT25

PROGRAMME OF EVENTS

Venue: International Scholars Centre, Federal University of Agriculture, Abeokuta

DAY 1: SUNDAY, JULY 20, 2025

S/No	Time (Hrs)	Event	Official(s) concerned
1.	12 noon	Arrival & Registration	LOC Members

DAY 2: MONDAY, JULY 21, 2025

S/No	Time (Hrs)	Event	Official(s) concerned
1.	7.00 – 9.00 am	Arrival of guests, participants and Registration	Participating Members
2.	9.30 – 9.40 am	Arrival of Keynote and Lead Speakers, VC, Principal Officers, Deans, Directors, Head of Centres and Departments.	Master of Ceremony (MC)
3.	9.40 – 10.00 am	Arrival of the Commissioner for Agriculture and Land Resources, Ministry of Agriculture, Ogun State and other Invited Guests	MC
4.	10.00 – 10.05 am	National and FUNAAB Anthems	ICTREC
5.	10.05 – 10.15 am	Welcome Address by the Vice-Chancellor, FUNAAB	Prof. O. B. Kehinde
6.	10.15 – 10.20 am	Address by the Dean, COLPLANT	Prof. Bola. Senjobi
7.	10.20 – 1030 am	Remarks by Commissioner for Agriculture and ………….	------------
8.	10.30 – 10.35 am	Reading of Citation of Keynote Speaker	
9.	10.35 – 11.05 am	Keynote address: Advancing Sustainable Food System Through Climate – Smart Crop Production	Prof. Oluwatosin Gabriel Director, IAR&T, Ibadan
10.	11.05 – 11.15 am	Goodwill messages and presentations	VC, DGs, MDs and all invited guests
11.	11.15 – 11.20 am	Vote of thanks	
12.	11.20 – 11.25 am	Announcements	MC
13.	11.25 – 11.30 am	FUNAAB and National Anthems	ICTREC

14.	11.30 – 11.45 am	Group Photographs	Invited guests and participants
15.	11.45 – 12.15 pm	Tea break	Catering Unit
16.	12.15 – 12.40 pm	Lead paper 1	Dr. Aladele Sunday E. Research Director (NACGRAB/NABRDA)
17.	12.40 – 13.05 pm	Lead paper 2	Prof. Jacob G. Bodunde Prof. of Horticulture & Land Scape Mgt., LASUTECH, Lagos State
18.	13.05 – 13.10 pm	Vote of thanks	Chairman, LOC
19.	13.10 – 14.00 pm	Lunch	All participants
20.	14.00 – 17.00 pm	Plenary Session (paper presentation)	Chairman, LOC

DAY 3: TUESDAY, JULY 22, 2025
TIME: 9.00 am – 6.00 pm
VENUE: SEMINAR ROOM, CEADESE, FUNAAB

S/No	Time (Hrs)	Event	Official(s) concerned
1.	9.00 – 1.00 pm	Paper presentation	Participants
2.	1.00 – 2.00 pm	Lunch	Catering Unit
3.	2.00 – 6.00 pm	Excursion	Participants
4.	6.00 pm	Closing	Chairman

DAY 4: WEDNESDAY, JULY 9, 2025

1.	8.00 – 9.00 am	**DEPARTURE**	

CHAIRMAN AND RAPPORTEURS FOR THE PLENARY SESSIONS

Parallel Session	Area of Specialization	Chairman	Rapporteurs
A	Crop Protection	Prof. Ishola S. Odeyemi	Dr. Caroline O. Filani Dr. Obinna S. Okwara
B	Horticulture	Prof. Lateef. A. Hahmed	Dr. Christiana O.Owolabi Mr. Olawale S. Ayeni
C	Plant Breeding and Seed Technology	Prof. Francis. A. Showemimo	Dr. Muibat M. Shittu Mr. Olushola O. Ajani
D	Plant Physiology & Crop Production	Prof. Thomas. O. Fabunmi	Dr. Olanrewaju Oni Dr. Nurudeen O. Adeyemi
E	Soil Science & Land Management	Prof. Jamiu O. Azeez	Dr. Anthony. O. Tobore, Mr. Ganiyu O. Bankole

ACKNOWLEDGEMENTS OF DONORS

WELCOME ADDRESS BY THE VICE-CHANCELOR OF THE FEDERAL UNIVERSITY OF AGRICULTURE ABEOKUTA

Olusola B. KEHINDE

Vice-Chancellor/Prof. of Plant Breeding and Genetics
Federal University of Agriculture, Abeokuta (FUNAAB),
Ogun State, Nigeria
kehindeob@funaab.edu.ng

Opening remarks:

ADDRESS BY THE DEAN, COLLEGE OF PLANT SCIENCE AND CROP PRODUCTION, FEDERAL UNIVERSITY OF AGRICULTURE, ABEOKUTA, OGUN STATE, NIGERIA

Bola A. SENJOBI

Dean/Prof. of Soil Science
College of Plant Science and Crop Production (COLPLANT),
Federal University of Agriculture, Abeokuta,
Ogun State, Nigeria
senjobiba@funaab.edu.ng

Welcome Address:

Distinguished guests,
Esteemed Colleagues,
Respected members of the Academic Community,
Students and friends.

It is with great pleasure and a deep sense of purpose that I welcome you all to this year's Biennial COLPLANT Conference, themed "Advancing Sustainable Food Systems through Climate-Smart Crop Production".

We gather at a time when the global call for food security and environmental sustainability is louder and more urgent than ever. As climate change continues to reshape agricultural landscapes across continents, our role as scholars, scientists, researchers and practitioners in the field of agriculture and food systems has never been more critical.

This conference is not just a convergence of minds; it is a clarion call to action. It is a platform where innovation meets necessity, where science and policy intersect, and where solutions to some of the most pressing challenges facing our food systems will be explored and articulated.

The theme we have chosen reflects a forward-thinking vision-one that acknowledges the undeniable impact of climate change on agriculture while also highlighting the potential of climate-smart practices to transform the way we produce crops, manage land, and secure livelihoods. From sustainable soil management and resilient seed system to smart irrigation and digital agriculture, the strategies we discuss here will shape the future of food generations to come.

Let us use this gathering to engage meaningfully, to share knowledge generously, and to challenge ourselves to think beyond the conventional. Let this be a time of reflection, collaboration and the birth of new ideas that will translate into impactful policies and practices.

I would like to use this medium to commend the organizing committee for their dedication and hard work in putting this event together.

To our keynote speakers, researchers and participants, thank you for bringing your expertise and passion to this important dialogue.

Once again, I welcome you all warmly and wish us a most fruitful and inspiring conference.

Thank you.

KEYNOTE ADDRESS DELIVERED AT THE 2ND BIENNIAL CONFERENCE OF THE COLLEGE OF PLANT SCIENCE AND CROP PRODUCTION

ADVANCING SUSTAINABLE FOOD SYSTEM THROUGH CLIMATE – SMART CROP PRODUCTION

Oluwatosin GABRIEL

Director/Prof. of Soil Science
Institute of Agriculture and Research and Training (IART),
More-Plantation, Ibadan, Oyo State, Nigeria
oluwatosingabriel@yahoo.com

Biography

Keynote paper

LEAD PAPER DELIVERED AT THE 2ND BIENNIAL CONFERENCE OF THE COLLEGE OF PLANT SCIENCE AND CROP PRODUCTION

ADVANCING SUSTAINABLE FOOD SYSTEM THROUGH CLIMATE-SMART CROP PRODUCTION

Prof. of Horticulture & Land Scape Management
Lagos State University of Science and Technology,
Ikorodu, Lagos State,
Nigeria
bodundejg@funaab.edu.ng

Jacob G. BODUNDE

Biography

Lead paper:

LEAD PAPER DELIVERED AT THE 2ND BIENNIAL CONFERENCE OF THE COLLEGE OF PLANT SCIENCE AND CROP PRODUCTION

PLANT IMPROVEMENT UNDER LIMITING BREEDING RESOURCES: A PANACEA FOR FOOD SECURITY

Sunday E. ALADELE

Research Director/Prof. of Plant Breeding and Genetics
National Centre for Genetic Resources and Biotechnology (NACGRAB),
National Biotechnology Research and Development Agency (NABRDA),
Ibadan, Oyo State, Nigeria
More-Plantation, Ibadan, Oyo State, Nigeria
oluwatosingabriel@yahoo.com

CITATION
SUNDAY EZEKIEL ALADELE
B.Sc. (Hons.) (Ife), M.Sc. (Kano), Ph.D. (Abeokuta)
Plant Breeding and Seed Technology

Biography

Dr Sunday Ezekiel ALADELE was born on October 14, 1960 and started his academic career at Saint Mary' Anglican Primary School, Igbaye in Osun State where he obtained First School Leaving Certificate. Thereafter, he proceeded to Offa Grammar School where he sat for the West African School Certificate Examination in 1981, B.Sc. (Hons.) in Plant Science in 1987 from the prestigious University of Ife (now Obafemi Awolowo University), He started his career as a Research Supervisor with the International Crops Research Institute for Semi- Arid Tropics (ICRISAT), Kano and later Research Associate with International Institute of Tropical Agriculture (IITA) between 1991 and 2001. He was later appointed as the Assistant Chief Scientific Officer by the Federal Ministry of Science and Technology, Abuja in October 2001 and subsequently transferred to National Centre for Genetic Resources and Biotechnology. Sunday Aladele was awarded a Ph.D. in Plant Breeding and Seed Technology in July 2009 from the Federal University of Agriculture, Abeokuta. He has a number of professional qualifications which include Seed Quality Management System, University of Arhus, (Denmark, 2023), Plant Variety Protection course (University of Wageningen, 2019), and Molecular Plant Breeding for Crop Improvement, ICRISAT, (India, 2011). He is a member of the Genetic Society of Nigeria, Nigeria Plant Breeders Association, and Biotechnology Society of Nigeria. Dr. S. E. Aladele was appointed the Executive Director and Registrar, National Committee on Naming, Registration and Release of Crop varieties and Animal Breeds and Fisheries in Nigeria in May 2014. Dr. Aladele has co-supervised M.Sc and Ph.D students from various universities including University of Ghana.

Lead paper

PLANT IMPROVEMENT UNDER LIMITING BREEDING RESOURCES: A PANACEA FOR FOOD SECURITY

Sunday E. Aladele

INTRODUCTION

Since the practice of agriculture began, eight to ten thousand years ago, farmers have been altering the genetic makeup of the crops they grow. Early farmers selected the best-looking plants and seeds and saved them to plant for the next season. Then, once the science of genetics became better understood, plant breeders used what they knew about the genes of a plant to select for specific desirable traits to develop improved varieties. Importance of plants to human life cannot be overestimated: No human being or animal can survive without consuming plants or their products (Pocket Ks, 2004; Osonubi, 2011). The rapid population growth and climatic challenges requires modern plant breeding techniques to ensure continuous crop improvement for food and nutrition security. In his Inaugural lecture titled "Too many foods for thought but no food on the table", Professor Olabode Lucas said that "in the modern world, no nation can truly be great if it cannot feed her populace and no meaningful progress can be made in other sectors of life if there is scarcity of food for the people" (Lucas, 2007). Considering the present global food crisis, whatever resources available to breeders, plant breeding must continue in a sustainable manner that will not jeopardize the food system of the nation.

DEFINITION OF TERMS

Plant breeding:	The science of purposefully manipulating plant genetics to create new varieties with desired traits
Plant improvement:	The process of modifying crops using traditional or laboratory techniques to create plants with desirable traits
Plant Genetic resources:	the genetic material of plants of actual or potential value, crucial for food security, agriculture, and scientific research
Genetic diversity:	The biological variation that occurs within species
Germplasm:	Collection of plants or seeds for all possible alleles of genes in a given crop
Genebank Core collection:	A subset of a larger germplasm collection, designed to represent the genetic diversity of the entire collection with minimal redundancy, facilitating efficient management and utilization of plant genetic resources (Figure 1)

Factors influencing food security

Food security: means that all people, at all times, have access to sufficient, safe, and nutritious food that meets their dietary needs and preferences for an active and healthy life (World Food Summit, 1996).

Food production

Food production is a key factor when it comes to food security, as it is necessary to ensure there is enough food to meet the needs of the population. Production of food is affected by a variety of factors, including agricultural practices, technology, climate, and access to resources. To increase food production and improve food security, it is important to invest in sustainable agriculture, food security technology, and research and development (General farm News, 2023).

Fig. 1: Genebank seed store

Food distribution

Food distribution networks are an invaluable tool for providing physical and economic access to food across the globe – without them, more people would be left without sustenance. Many forces have a dramatic effect on these networks, from population growth to political unrest. While infrastructure and technology play an important role in creating efficient distribution, an investment in human capital is just as important.

Food safety

Contaminated food can cause illness and reduce the body's ability to utilize nutrients

Food Nutrition

Good nutrition is essential for overall health and well-being, impacting on everything from physical and mental health to disease prevention and longevity. Food is more than having something to consume, it is the foundation of our healthier and more fulfilling life

Socioeconomic factors

- Poverty - when people have less money, they cannot afford food and they become unable to work. Families in developing countries spend much of their income on food.
- Social unrest in some farming communities where the farmers are displaced can limit the available food in the country.
- Inflation and economic instability
- Population growth

Climate change

Global climate change is taking a devastating toll on food security as weather patterns, harvests, and access to water and fertile land are all being affected. As temperatures continue to rise, more extreme weather patterns become increasingly likely with profound implications for food production. Global warming is increasing temperatures by around 0.2°C every 10 years. Rainfall is increasing in some places, but decreasing in others. Higher temperatures and unreliable rainfall make farming difficult, especially for those farming *marginal lands*, who already struggle to survive. Even *advanced countries (ACs)* can be affected by drought. Countries such as Russia and Australia are huge exporters of wheat and barley respectively. When they suffered drought there was less food available globally and global food prices increased, leaving the poor most vulnerable.

State of the food insecurity and Nutrition in the world 2024

The world has been facing serious food insecurity over the years. The covid-19 exposed how vulnerable countries are when it comes to food security. Africa and Asia continents are the worst hit on food and nutrition insecurity (Table 1). North African countries are better off than other sub-Saharan African countries and West Africa seems to be badly affected.

Table 1. Undernourished population in millions

Continents	2022	2023	Region	2022	2023
World	763.4	757.2	North Africa	23.0	22.7
Africa	307.7	309.7	Sub-Sahara Africa	284.4	287.0
Asia	395.7	393.2	East Africa	143.3	140.5
Latin America	49.7	43.7	Central Africa	61.3	63.2
Oceania	7.1	3.4	South Africa	6.9	6.7
North America & Europe	NR	NR	West Africa	73.1	76.6

FAO, IFAD, UNICEF, WFP & WHO, 2024

Purpose of Crop Improvement

A breeder should clearly define the breeding goals before commencement.

High yield:	This is to increase the yield qualitatively and qualitatively
Pest and disease resistance:	There may be need to breed for resistance to address the outbreak of certain disease or attempt introgression of some resistant traits to an existing variety
Drought tolerance:	Generally, many accessions are screened to select for flood, drought and heat tolerance
Nutrition enhancement:	Breeder could target certain level Vitamin A or other micro mineral elements such as Iron and Zinc
Plant height reduction:	Increase or general architecture: Sometimes the breeder needs to develop genotypes that are good for intercropping or short varieties for mechanization
Non-shattering	This is common in soybean and cowpea
Elimination of dormancy:	It is essential in some leguminous crops such as pigeon pea
Improvement in fruits shelf life:	Tomatoes, pepper, okra, eggplant
Elimination of toxic substances:	Some crop varieties contain certain substances that can be dangerous for human health if it exceeds maximum permissible limit such as HCN in cassava

Limiting breeding resources

1. **Genetic diversity** – inadequate genetic diversity restricts the ability to introduce desirable traits which can reduce the vulnerability to biotic and abiotic stresses.
2. **Field and laboratory**: Plant breeding requires adequate space for Screen houses, laboratories, and field for basic and advanced trials.
3. **Human resources:** Inadequate trained skilled personnel in breeding, pathology, molecular biology scientists ETC.
4. **Natural resources:** Climate and environmental conditions can be unpredictable, especially during multilocation trials across different locations within the country.
5. **Funding:** Plant breeding requires adequate funding from conceptualization to product development and the official registration and release to farmers and other end users.

Differences between International Research Centers and NARIs and Universities

International Agric Research Centres	National Agricultural Research Institutes	University of Agriculture
Funding available before project commencement	Funding may be available at commencement but not guaranteed continuously	Only specific externally funded project can guarantee funding to the completion of breeding programme.
Material resources available in abundance	Materials may or may not be adequate	Materials may or may not be adequate
Access to the state of the earth facilities	Outdated equipment and limited screen houses	Inadequate breeding facilities
Wider collaboration with other CG Centres	Limited collaborations due to mandate crops	Limited collaborations outside the faculties
Availability of Experts in various associated disciplines	Inadequate human resources and Experts	Limited number of Experts within the breeding programme

Strategies for effectively managing limited resources in Plant breeding

Managing resources in plant breeding is critical for ensuring successful outcomes, enhancing efficiency, and maximizing the potential of breeding programs.

1. **Develop a Clear Breeding Plan**
   Prioritize Traits: Identify which traits are essential and prioritize them based on market demand, environmental factors, and genetic potential.
2. **Optimize Genetic Resources**
   Diversity Assessment: Evaluate the genetic diversity available in your germplasm collection to identify suitable parents for crossing.
   Use of Marker-Assisted Selection (MAS): Incorporate molecular markers to enhance selection efficiency and accuracy in breeding programs.
   Collaboration: Collaborate with genetic resource banks and other breeding programs to access diverse germplasm.
3. **Research and Development**
   Invest in Genomic Tools: Utilize modern biotechnology and genomic tools to accelerate the breeding process, such as genome editing and sequencing technologies.
   Field Trials: Conduct well-designed field trials to test the performance of new cultivars under various environmental conditions.
4. **Human Resource Management**
   Training and Development: Invest in training of staff to keep them updated on the latest breeding techniques and technologies.
   Collaboration: Encourage collaboration among plant breeders, geneticists, agronomists, and other specialists to foster knowledge exchange and innovation.
5. **Financial Resource Management**
   Budget Planning: Create a detailed budget that includes all necessary expenditures (e.g., seeds, facilities, labor) and track expenses to stay within budget.
   Funding Opportunities: Seek funding from government grants, private sector partnerships, and research organizations to support breeding programs.
6. **Efficient Use of Time**
   Activity Scheduling: Plan and schedule activities to make the best use of the growing season and other time-sensitive tasks.

Timeline: Establish a realistic timeline for achieving these breeding goals, including intermediate milestones

Pathway to successful Plant breeding and Crop improvement

Farmers and end users' preference can easily be obtained through survey while the breeders need to access the Core collection with diverse traits and Pre-breeding data to select pure line materials for making crosses to obtain traits of interest.

Research procedures

Step one – Product design based on survey result
Step two – Parental selection of pure lines or accessions from genebank
Step three – Create new genetic variation using modern tech.
Step four - Preliminary trials – (Involve farmers at this stage)
Step five – Advanced trials on the researchers' field
Step six - Multilocation trial across different agro-ecologies
Step seven – On-farm testing
Step eight – Official registration and release of the varieties

Consultations, Collaboration and Cooperation

Basic Consultations required before the commencement of any breeding project

Donors: *What aspect of food security do they want to intervene?*
The donor may be interested in high yielding climate smart variety or nutrient efficient genotypes.

Farmers: *What challenges are militating against their productivity?*
The needs of farmers vary from one agroecology to another. Some face biotic stresses such as *striga and* insect pests while others face the challenge of abiotic stresses such as flood and drought among others.

Genebank Curators: *Can the core collections with necessary data be provided?*
Information on characterization of core genebank collection should be available to the breeders. The Curator should be willing to share all the available data in order to fast track the breeding of new

End-users: *Consumer preference*:
There is no need developing a variety that will not be adopted. Consumer provide information on their choice of varieties. e.g. orange flesh potatoes.

Relevant Collaborators needed by the Breeders

Pathologists:	To support in screening for diseases
Agronomists:	Provides advice on the best agricultural practices
Entomologists:	Provide some insights if the breeder is interested in insect resistance
Food Scientists:	There is need for their collaboration after the product development
Laboratory Scientists:	A number of laboratory analyses are required before document for variety release is submitted to the National Variety Release Committee.
Social Scientists and Statistician:	The expertise of Statistician is very crucial at the planning stage of breeding experiment and during data analysis
Other Breeders of similar crop:	There may be need to compare note with breeders of similar crops when the breeding programme is in progress (Fig. 2)

Figure 2; Inspection of sorghum field bv breeders

Important stakeholders that breeders need their Cooperation

Farm managers:	To ensure the right field is allocated and is protected
Field technician:	Engage the technician in collecting qualitative data
Finance officers:	To facilitate prompt release of project funds
Administrative managers:	Provide smooth documentation and timely approvals of necessary budgets
Policy makers (Registration & Release):	Technical and National need to be carried along during field inspection

Conclusions and Recommendations

Conclusions

1. Crop improvement is not a one man show, collaboration with stakeholder is a must;
2. Farmers play a critical role in crop improvement of any country;
3. Food insecurity is increasing in Sub-Saharan Africa generally, and particularly in West and Central Africa;
4. Modern biotechnology tools are essential to accelerate progress in plant breeding;
5. Productive Plant breeding requires adequate funding to succeed.

Recommendations

1. Continuous Plant breeding is essential to meet the challenges of population growth and erratic climatic issues for global food security.
2. There should be a conscious Conservation and utilization of Plant genetic diversity of the country. This will constantly provide opportunity for breeders to have access to different traits that are important for food security.
3. Regular training and retraining of breeders and relevant scientists are very crucial to crop improvement, especially in modern biotechnology such as gene editing.
4. Basic Seed testing laboratory equipment should be provided to all Crop Breeding institutions and departments by the government through special intervention funds.
5. Multinational and viable National Seed Companies should give back to the breeding institutions to promote further crop improvement. This may come in form of equipment donation and support for short time trainings.

References:

FAO, 2024. The State of food security and Nutrition in the World jointly reported by UN Agencies, IFAD, UNICEF, WFP and WHO. FAO flagship publication.

General farm News, 2023. Ten key factors Affecting Food Security and how we can address them. https://farmloans.com/general-farm-news/10-key-factors-affecting-food-security-and-how-we-can-address-them/

Lucas E. O. 2007. Too much food for thought, but very little for the table: an inaugural lecture delivered at the University of Ibadan on Thursday, 13 December, 2007, Ibadan University Press.

Osonubi, O. 2011. The Journey so far: A valedictory lecture delivered at the Department of Botany, University of Ibadan, 16th March, 2011. 51pp

Pocket Ks, 2004. Conventional Plant Breeding Pocket K. No. 13: page 1 (http://www.isaaa.org/kc).

Suart Bowden, 2023. Factors influencing food security and its challenges. J. of Food Microbial Safety Hygene. 8. 261

MEMBERS OF THE LOCAL ORGANIZING COMMITTEE (LOC) OF THE 2ND BIENNIAL CONFERENCE OF THE COLLEGE OF PLANT SCIENCE AND CROP PRODUCTION, COLPLANT'25

CENTRAL WORKING COMMITTEE

1.	Prof. A. A. Soretire	Chairman
2.	Prof. Joy N. Odedina	Vice-Chairman
3.	Prof. O. A. Oduwaye	Secretary
4.	Mr. P. A. S. Soremi	Assistant Secretary
5.	Dr. Tolulope O. Kehnde	Treasurer

FUND RASING SUB-COMMITTEE

1.	Prof. Joy N. Odedina	Chairman
2.	Mr. P. A. S. Soremi	Member
3.	Prof. G. A. Ajiboye	Member
4.	Prof. M. O. Atayese	Member
5.	Prof. O. I. Lawal	Member
6.	Prof. M. A. Busari	Member
7.	Dr. Caroline O. Filani	Member

SCIENTIFIC/TECHNICAL SUB-COMMITTEE

1.	Prof. O. A. Oduwaye	Chairman
2.	Prof. O. R. Adeyemi	Member
3.	Prof. G. A. Ajiboye	Member
4.	Prof. Patience M. Olorunmaiye	Member
5.	Dr. N. O. Adeyemi	Member
7.	Dr. B. A. Yekini	Member
8.	Mr. O. J. Fadeyi	Member

PUBLICITY SUB-COMMITTEE

1.	Prof. O. M. Olosunde	Chairman
2.	Prof. E. O. Idehen	Member
3.	Prof. I. O. Lawal	Member
4.	Dr. Muibat M. Shittu	Member
5.	Dr. Ayooluwa A. Olubode	Member
6.	Mr. G. O. Bankole	Member

WELFARE/LOGISTIC SUB-COMMITTEE

1.	Dr. Florence A. Olowokere	Chairman
2.	Dr. Ayooluwa A. Olubode	Member
3.	Dr. Tunrayo T. Joseph-Adekunle	Member
4.	Dr. Tolulope O. Kehinde	Member
5.	Dr. Caroline O. Filani	Member
6.	Dr. Gbemisola O. Otusanya	Member
7.	Dr. Muibat M. Shittu	Member
8.	Dr. O. A. Osinuga	Member

SCIENTIFIC PAPERS

Reaction of Twenty-Nine Fonio (*Digitaria* species) Accessions to Leaf Blight Disease in Abeokuta, Ogun State, Nigeria

[1]Yekini, B. A.*, [1]Adigbo, S. O. [2]Enikuomehin, O. A., [2]Ishola, R. O., [2]Idowu, S. K. and [2]Adenekan, O. M.

[1] Crop Research Programme, Institute for Food Security, Environmental Resources and Agricultural Research (IFSERAR), Federal University of Agriculture, Abeokuta, Nigeria.

[2] Department of Crop Protection, Federal University of Agriculture, Abeokuta, Nigeria.

ABSTRACT

Experiment was conducted to determine the incidence and severity of leaf blight disease on twenty-nine fonio accessions. The trial was conducted during the 2024 early cropping season at the Teaching Research Farm, Federal University of Agriculture Abeokuta, Ogun State, Nigeria. The trial comprised of twenty-nine fonio accessions spread out in a Randomised Complete Block Design (RCBD) that was replicated three times. Data collected were subjected to Analysis of Variance (ANOVA) using Minitab software version 17 and the mean was separated using Tukey test at $p \leq 0.05$. The result of percentage disease incidence and resistant level of twenty-nine accessions screened for leaf blight disease under natural infection showed a significant difference. The results revealed that *D. exilis* did not show any leaf blight symptom but there was significant variation in disease incidence and severity express by *D. iburua*. Dinat (80.00 %) had the highest disease incidence, followed by Amundel (75.00 %) disease incidence. The disease severity ranged with the values from 0.00-4.500. The resistant level showed that thirteen accessions were highly resistant, eleven were resistant and five were moderately resistant to leaf blight disease during the trial. The study recommended that the resistant genotypes could be further planted in other agro ecological zone to determine resistant accessions against leaf spot disease in fonio. In conclusion, assessment of the tested fonio accessions for resistance to leaf blight disease is important in the management of fonio disease throughout the growing state in order to prioritize disease management strategy and increase the yield output of the farmers.

Key words: Accessions, digitaria, disease fonio, leaf blight

***Corresponding Author**: yekiniba@funaab.edu.ng

INTRODUCTION

Fonio (*Digitaria* spp.) is a key member of the grass family *Poaceae*, native to West Africa, where it is often referred to as Acha (Yilmaz, 2023). It is hardy, drought-resistant cereal which is known for its ability to grow in poor, sandy soils, making it particularly well-suited to challenging agricultural environments (Diop *et al*., 2018). Fonio plants are typically short, reaching heights between 30 and 80 cm, with slender, erect stems and narrow green leaves. The plant produces tiny grains, about 1 to 2 mm in diameter, known for their white color (Abdul and Jideani, 2019). Due to its higher amino acid content, fonio is often referred to as the most nutritious cereal grain compared to others like wheat, rye, and barley (Koreissi-Dembélé *et al*., 2013). Moreover, its gluten-free nature makes it a suitable option for people with celiac disease (Zhu, 2020). Fonio is a very nutritious crop but is considered to be an underutilized and under research crop. Besides, the cultivation is restricted to dry savannah zones of Nigeria. Fungi pathogen is one of the major threats to fonio production in the tropics particularly in Nigeria. This pathogen has been reported to cause up to 45 % yield reduction on grown fonio (Zinsou *et al*. 2020). The use of resistant varieties is the most economical and effective way of controlling fungal diseases mainly on resource constrained farmers' fields. However, with this small millet, a holistic approach is needed to address challenges related to diseases. Consequently, there is limited scientific data on its disease incidence and severity, disease resistance, insect pests, diseases and insect pest management, genetic diversity and optimal agronomic practices. This knowledge gap hinders efforts to improve yields and promote fonio as a sustainable crop in the face of climate change and population growth (Padulosi *et al*., 2014). To achieve this goal, a good management strategy of the fungal pathogen requires selection of productive and resistant fonio accessions. Therefore, the studies aim to determine the incidence and severity of leaf blight of fonio on the accessions.

MATERIALS AND METHODS

Location

The experiments were conducted at the dry upper valley of FADAMA and the Crop Protection Laboratory, College of Plant Science and Crop Production, Federal University of Agriculture Abeokuta, (FUNAAB). The farm is located within latitude 7°20' N and longitude 3°23' E with an altitude of 76 m above sea level. The study area is located in the forest-savanna transition zone.

Source of thirty fonio seeds

The thirty fonio accessions were sourced from National Cereal Research Institute (NCRI), Acha House Station, Jos Plateau State, Nigeria (Table 1).

Experimental design and treatments

The experiment was laid out in Randomized Complete Block Design (RCBD) and replicated three times. The total experimental plots area (73 m x 8 m) and plot size 2 m x 2 m. Two species of the fonio used were *Digitaria exilis* Stapf-white fonio and *Digitaria* iburua Stapf-black fonio. Each of the species were dibbled at the spacing of 50 cm in row sowing.

Disease assessment

At the first appearance of the disease, data were collected on disease symptoms. Leaf blight incidence and severity were taken at about 15 cm foot size in the central row, and calculate using the formulae below. The severity scale is presented in Table 2.

$$DI\ (\%) = \frac{Number\ of\ diseased\ plant}{Total\ number\ of\ plants\ per\ plot}\ \text{x}\ 100$$

Disease Severity (DS) was calculated using the formulae.

$$\text{Disease severity} = \frac{\sum \text{n}}{\text{N x S}}\ \text{x}\ 100$$

Where: Σ is Summation, n is number of infected leaves, N is number of leaves assessed, and S =maximum numerical grade.

Statistical analysis

Data collected were subjected to Analysis of Variance (ANOVA) using Minitab software version 17 and the mean was separated using Tukey test at $p \leq 0.05$.

RESULTS AND DISCUSSION

Fonio foliar diseases observed on the field

The results revealed that leaf blight was observed on fonio for the first time in Abeokuta, Ogun State, Nigeria during the growing season. The symptom of leaf blight started with a dried tip of the leaf and progress to other leaf part (Figure 1a). The accessions *D. iburua* are susceptible while *D. exilis* was totally immune to the disease. The disease incidence and severity differed across the twenty-nine fonio accessions for each symptom. The highest incidence and severity values was found in *D. iburua* which showed that this species is more vulnerable to fonio leaf blight. This may be due to environmental conditions such as temperature, relative humidity and level of soil fertility. Manza *et al.* (2013) reported highest

Table 1: List of thirty fonio accessions

S/No	Accessions	S/No	Accessions
1	Guzuk 2	16	Nebang
2	Achimawai	17	Jakalak
3	Mboseke	18	Amundel
4	Mawoi	19	Nasheleng
5	Nyamat	20	Ganawuri
6	Badama	21	Nanagai
7	Dipya	22	Dinat
8	Siken	23	Zor
9	Loma	24	Pelking
10	Chen	25	Machach
11	Gong-arandong	26	Jarab
12	Dicksun	27	Dampep
13	Gotip	28	Sunpiya
14	Chu	29	Danto
15	Fang-roi	30	Ebuth

disease incidence and severity of Curvularia leaf spot occurrence in Riyom, Plateau State of Nigeria.

Percentage disease incidence and resistant level of twenty-nine accessions screen for fonio leaf blight disease under natural infection

The result of percentage disease incidence and resistant level of twenty-nine accessions screen for fonio leaf blight disease under natural infection showed a significant difference among the twenty-nine fonio screened (Table 3). The result showed that *D. exilis* did not show any leaf blight symptom but *D. iburua* showed a variation in the degree of disease incidence. Dinat (80.00 %) had the highest disease incidence, followed by Amundel (75.00 %) disease incidence. The disease severity ranged with the values of 0.00-4.500. The resistant level showed that one accessions was highly resistant, eleven were resistant, six were moderately resistant, nine were moderately susceptible and two accessions were susceptible leaf blight disease during the trial.

Table 2: Disease severity rating scale for leaf blight disease of fonio

Grade/Numerical value	Symptom expression (% leaf area infected)	Rating
0	Spotless leaves	Highly Resistant (HR)
1	Scattered pin point brown spot on the leaves (1-10.9)	Resistant (R)
2	Widened brown spots with traces of yellow background on the leaves (11.-25.9)	Moderately Resistant (MR)
3	Coalescing of brown spots to form extended necrotic areas with obvious yellowing of background tissues (26-50.9)	Moderately Susceptible (MS)
4	Extensive browning and necrosis of foliar tissue which tends to wilting of the entire leaf (51-75.9)	Susceptible (S)
5	All the leaves with brown spot on the entire plant (76 % above)	Highly Susceptible (HS)

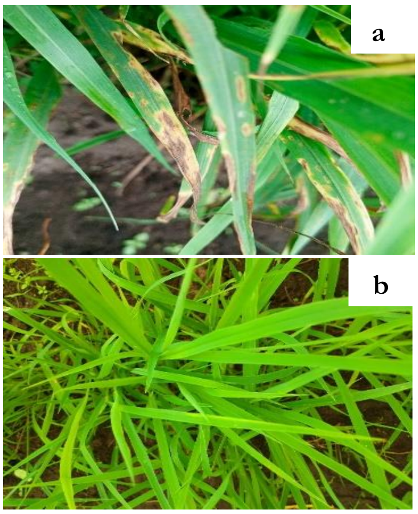


Figure 1: Leaf blight of fonio (a) and Healthy fonio(b)

CONCLUSION

The study revealed the occurrence of leaf blight on fonio plant at various stages. The study also revealed that *D. ibruua* (black fonio) accessions are more susceptible to fungal infection than *D. exilis* (white fonio). The resistant levels for leaf blight disease showed that thirteen accessions were highly resistant, eleven were resistant and five were moderately resistant to blight pathogen.

Table 3: Percentage disease incidence and resistant level of twenty-nine fonio accessions screened for leaf blight disease under natural infection

Treatments	Disease incidence (%)	Disease severity	Status
Guzuk 2	0.00d	0.00d	HR
Achimawai	0.00d	0.00d	HR
Mboseke	0.00d	0.00d	HR
Mawoi	0.00d	0.00d	HR
Nyamat	0.00d	0.00d	HR
Badama	0.00d	0.00d	HR
Dipya	0.00d	0.00d	HR
Siken	0.00d	0.00d	HR
Loma	0.00d	0.00d	HR
Chen	0.00d	0.00d	HR
Gong-arandong	0.00d	0.00d	HR
Dicksun	0.00d	0.00d	HR
Gotip	1.67cd	0.33cd	HR
Chu	6.67bcd	1.00a-d	R
Fang-roi	5.00bcd	1.00a-d	R
Nebang	20.00ab	1.17a-d	R
Jakalak	11.67bcd	1.50abc	MR
Amundel	13.33bcd	1.50abc	MR
Nasheleng	13.33bcd	1.00a-d	R
Ganawuri	11.67bc d	1.17a-d	R
Nanagai	6.67bcd	0.67bcd	R
Dinat	10.00bcd	1.33a-d	R
Zor	3.33cd	0.50cd	R
Pelking	15.00bcd	2.33a	MR
Machach	16.67bc	2.00ab	MR
Jarab	5.00bcd	0.67bcd	R
Dampep	5.00bcd	0.83bc d	R
Sunpiya	10.00bc d	1.00a-d	R
Danto	35.00a	2.33a	MR
Means	33.10	1.930	
SE	3.30	0.196	
CV (%)	93.09	94.77	

Means in the same column followed by different alphabets are significantly different ($p \leq 0.05$) using Tukey. SE means Standard Error while CV means Coefficient of Variation. HR=Highly Resistant, R=Resistant and MR=Moderately Resistant

REFERENCES

Abdul, S. D. and Jideani, A. I. 2019. Fonio (*Digitaria* spp.) breeding. In J. M. Al-Khayri, S. M. Jain, and D. V. Johnson (Eds.), *Advances in Plant Breeding Strategies:* Cereals 5: 47-81.

Diop, B. M., Gueye, M. C., Agbangba, C. E., Cissé, N., Deu, M., Diack, O. and Barnaud, A. 2018. Fonio (*Digitaria exilis* [Kippist] Stapf). *Ethnobiology Letters*, 9(2): 150-165.

Koreissi-Dembélé, Y., Fanou-Fogny, N., Hulshof, P. J., and Brouwer, I. D. 2013. Fonio (*Digitaria exilis*) landraces in Mali: Nutrient and phytate content, genetic diversity and effect of processing. *Journal of Food Composition and Analysis*, 29(2): 134-143.

Mamza, W. S., Zarafi, A. B, Dachi, S. N., Bright E. O. and Ukuwngwu, M. N. 2013. Incidence and severity of Curvularia leaf spot on *Digitaria iburua* (fonio) in Riyom, Plateau State, Nigeria. P 88. In: Hall, R.A., P. Rudebjer, S. Padulosi. (eds.) 2013. 3rd International Conference on: Neglected and Underutilized Specie. (NUS): for a Food-Secure Africa. Accra, Ghana, 25-27

September 2013. Book of Abstracts. Bioversity International, Rome, Italy.

Padulosi, S., Amaya, K., Jäger, M., Gotor, E., Rojas, W. and Valdivia, R. 2014. A holistic approach to enhance the use of neglected and underutilized species: The case of Andean grains in *Bolivia and Peru. Sustainability*, 6(3): 1283–1312.

Yilmaz, M. S. 2023. Fonio (*Digitaria* Spp.) and Its Potential for Use in Foods. *Some Novel Applications in the Food Industry*, 105-124.

Zhu, F. 2020. Fonio grains: Physicochemical properties, nutritional potential, and food applications. *Comprehensive Reviews in Food Science and Food Safety*, 19(6): 3365-3389.

Zinsou, A. V., Sekloka,. E, Dramane, M., Tchemadon, G., Kora, T. A., Djaouga, M. N. and Kanlindogbe, C. (2020). Curvularia leaf spot on white fonio accessions in the commune of Boukoumbe in north Benin. *Journal of Animal and Plant Sciences*. 44(3):7695-7706 https://doi.org/10.35759/JAnmPlSci.v44-3.2.

Emerging Issues, Challenges and Prospects of Pesticidal Plants as Viable Alternative to Synthetic Chemicals

[1,2]Omoleye, M. T.*, [1,2]Laoye, F. T., [1]Oladigbolu, Y. O., [1]Adeji, A. O. and [1]Bobinihi, M. O.

[1] Cocoa Research Institute of Nigeria, Ibadan, Nigeria (CRIN), Crop Protection Division.
[2] Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.

ABSTRACT

Synthetic pesticides have successfully been used in the management of diseases as well as controlling pest populations from time immemorial. However, it is well known that their arbitrary application on crops has negative effects not only on the plants but also on the environment as pertinent issues relating to safety of human health due to its toxicity, high residual in crops, negative impact on the environment as well as non-biodegradability and huge environmental issues that might arise due to its usage and its impact on the environment are threatening its continued use which necessitated the thirst and call for an alternative. There had been various calls/advocacies for adoption of alternative means of pest control and disease management which led to various studies and eventual formulation, development and adoption of some pesticidal plants(reported to be less toxic especially on non- target organisms, ecofriendly, less persistent in soil, and with high biodegradability capacity) as such serving as viable alternatives to the synthetic pesticides and highly effective in the management of pests that have developed resistance to synthetic pesticides thereby reducing over dependence on synthetic chemicals. This paper aim to review some of the emerging issues/challenges facing the adoption of pesticidal plants as an alternative to synthetic chemicals and the futuristic prospects of its usage in the country with the sole aim of harnessing its potential in Integrated Pest Management (IPM) as part of management strategies in curbing the menace of pests and diseases that might have developed resistance to synthetic pesticides.

Key words: Biodegradability, formulation, integrated pest management (IPM), pests and diseases, toxicity

***Corresponding Author:** omoleyetoluwalope@gmail.com

INTRODUCTION

In the time past (for more than five decades now), the main method used in the control of pest and diseases and protection of crops has been chemical method (use of chemical pesticides i.e conventional synthetic insecticides) (Kumar and Singh, 2015; Anani *et al.,* 2020; Kandar, 2021) in the control and management of pests and diseases. Although pesticides has successfully been used in the management of diseases as well as controlling pest populations, it is well known that their arbitrary application on crops has negative effects not only on the plants but also on the environment as pertinent issues related to safety, health and environmental impact assessment of its effect on plants and humans are threatening the continued use of synthetic pesticides as various researchers have reported the presence of pesticides residuals in various food products whose consumption can lead to different diseases in humans (Omoyajowo *et al.,* 2018, Li *et al* ., 2022, Onwujiogu *et al.,* 2022). The World Health Organization (WHO) reported that approximately two hundred thousand people especially were killed on a yearly basis as a result of chemical pesticide poisoning as a result of residual pesticide being beyond the recommended Maximum Residual limit (MRL) (Omoyajowo *et al.,* 2018), as such it necessitated the search and call for alternative means of pest and disease control that will not only be eco-friendly but also less toxic/lethal to crops and in the long run result into sustainable crop production (Copping and Menn, 2000; Gupta and Dikshit, 2010; Mazid *et al.,* 2011; Chandler *et al.,* 2011).

Biopesticides (pesticidal plants) is the most important and rational choice to chemical pesticides as they have been reported to be effective in pest population control, diseases management and actualization of sustainable crop production (Varsha and Shahida, 2020). In general, pesticidal plants are considered environmentally friendly alternatives to synthetic chemical pesticides derived from natural sources- extracts of plant materials (Gupta and Dikshit, 2010; Glare *et al.,* 2012). Possible replacement with biopesticide (pesticidal plants) as a more rational choice for pest management to chemical synthetic ones arose due to need by farmers to have safer pesticides to protect their crops as it allows for sustainable approach for improved crop production (Mishra *et al.,* 2015; Ayilara *et al.,* 2022). Several factors point to biopesticides as viable alternative as specifically, they are reported to be highly effective, bio-degradable, target-specific to pests, less toxic to humans and environmentally friendly (Gupta and Dikshit, 2010; Prabha *et al*., 2016; Kumar *et al.,* 2021). They are manufactured from natural substances such as plants, microbes, and nanoparticles that are of biological origin as a sustainable control measure for pests (Kumar *et al.,* 2021).

According to the United States Environmental Protection Agency (EPA), Biopesticides can be defined as 'certain types of pesticides gotten from natural materials such as animals, plants, bacteria, and certain minerals', It is a generic term for pest control measures that utilize bioactive microbes derived from plant and animal sources for sustainable crop protection naturally (Glare *et al.,* 2012 In another word, it could be defined as any remedy that is of biological origin which is produced with the sole aim of controlling, destroying, and repelling microbes (DAFF, 2015).

Pesticidal plants naturally have defence mechanisms which made them to be capable of repelling, killing and/or controlling pests (insects, fungi, bacteria, nematodes, mites etc). The mode of action of pesticidal plants is divers (Table 1) and they can be used as strategy for management of pest and disease, companion plant that inhibits pests, oil extracts of the plants can be used as pesticide which inhibits and/or kill pests, and phyto-pesticide (biopesticide formulation that is of plant origin).

Complete processes involved in the formulation of biopesticides

The complete process involved in the development of plant-based biopesticides extract (pesticidal plants) is presented in Figure 1.

Pre-Extraction
↓
Screening of extracts
↓
Extraction of crude extracts
↓
Separation of antioxidant
↓
Identification and Quantification
↓
Bio-efficacy study of crude extracts
↓
Formulation (Dry or Wet)
↓
Storage of formulation
↓
Commercialization of products (biopesticide).
↓
Marketing

Figure 1: Flow chart of the process involved in the formulation of biopesticides from plant-based extracts (Kandar, 2021).

Table 1: Few examples of Pesticidal Plants currently used in Nigeria as pest control.

Common name	Botanical name	Mode of action
Neem	Azadirachta indica	Insecticidal, Fungicidal
Tobacco	Nicotina tabacum	Insecticidal
Ryania	Ryania speciosa	Insecticidal
Marigold	Calendula officinalis	Nematicidal
Hot pepper	Capsicum annuum	Pesticidal
Garlic	Allium sativum	Insecticidal, Fungicidal
Pyrethrum	Chrysanthemum cinerariaefolium	Insecticidal
Basil	Ocimum basilicum	Insecticidal, Fungicidal
Rotenone	Derris ellptica	Insecticidal, Piscicida
Strychnine	Strychnos nux-vomica	Insecticidal
Henna	Lawsonia inermis	Insecticidal
Blunt leaved Senna, Coffee Senna	Senna obtusifolia	Insecticidal
Pepper fruit	Dennettia tripetala	Insecticidal
Balsam spurge	Euphobia balsamifera	Insecticidal

Okwuete, 2012

Emerging issues in the adoption of pesticidal plants

There are diverse emerging issues that arose as a result of the adoption of pesticidal plants in the control of pests and diseases in Nigeria. Some of such issues include (but not limited to):

- **High cost of production**
  The cost of formulation of phyto-pesticides is high, and this can be a barrier to its adoption as a viable alternative in place of synthetic chemicals, and this can serve as a barrier to its adoption especially for small-scale farmers.
- **Lack of technical know-how**
  The adoption of phyto-pesticides requires specialized knowledge and skills which is lacking amidst small scale farmers and as such can be a challenge in areas with limited expertise.
- **Inconsistent field performance**
  Pesticidal plants may not perform consistently in different field conditions which can affect their adoption. This is because pests and diseases prevalence in a particular biome depends on some factors such as: plant age, climatic condition, geographical location and soil type. Hence the need to conduct arrays of researches both in vitro and in- vivo (in the field or under controlled environment-green house) in order to determine the efficacy of the plant pesticides as inconsistency in field performance is currently an issue which must be resolved for it to be accepted/adopted as viable alternative without prejudice by farmers
- **Poor Infrastructure**

Lack of adequate storage as well as transportation facilities can affect the efficacy and availability of pesticidal plant extracts (biopesticides).

- **Inconsistent Government Policies**

Inconsistency in the policies and regulations lay down by successive Nigerian government is another barrier that can hinder the adoption of pesticidal plants as viable alternative for synthetic chemicals.

- **Limited Awareness**

Many farmers reside in the rural part of the country and do not have access to information on social and print media as regard the benefits and availability of phyto-pesticides as an alternative to synthetic chemicals as such this can limit its adoption.

- **Public Perception**
  Many stakeholders (farmers and the general populace at large) have concerns

about s efficacy of pesticidal plants in remediating pest attack.

- **Regulatory Framework**
  The regulatory framework for the use of phyto-pesticides in Nigeria is currently inadequate and unclear, and this can affect its adoption as there must be concrete and adequate regulations governing the usage of plant extracts that has pesticidal potential as biopesticide.
- **Scaliabilty**
  Biopesticides may not be scalable for large-scale farming operators and this can limit their adoption.

Challenges of adopting pesticidal plants

Some of the challenges encountered include:

1. Instability: Pesticidal plants are not as stable as synthetic pesticides and they easily breakdown in the presence of sunlight.
2. Effectiveness: Pesticidal plants can take longer time to work than synthetic pesticides
3. Low Research and Development: Although, there have been an increase into the research of pesticidal plants as a viable alternative to synthetic chemicals, however, more research work need to be done in the aspect of formulation and commercialization in order to make it compete variably well in the market with the synthetic ones.
4. Environmental Impact Assessment: There is need to study the impact that the adoption of pesticidal plants has on the biotic and abiotic component of the ecosystem as though it is a general belief that pesticidal plants are eco-friendly but they still have underlying negative impacts on animals and plant diversity (most especially the non-target organisms).
5. Pollution: the chief reason for the call and search for a viable alternative to synthetic chemicals was due to toxicity and non-biodegrability of synthetic chemicals in the environment (soil/land/water) resulting into pollution of soil and/or water bodies, hence the adoption of phyto-pesticides (plant extracts that has pesticidal capabilities). However, although it is believed to be less toxic and biodegradable, Pesticidal plants can still contribute to pollution, if correct dosage is not used.

Solutions to emerging issues regarding adoption of pesticidal plants in Nigeria

Below are some possible solutions than can help in addressing emerging issues raised in the course of this review work.

- Inconsistency issues: Researchers need to work more and develop strategies to ensure consistent field performance of pesticidal plants both in-vitro (in the laboratory) and in-vivo (in the field or under controlled environment such as green house).
- Addressing scaliability issues: there is need to develop strategies that will scale up the production and use of pesticidal plants that will meet the demand of large-scale farmers.
- Regular monitoring and evaluation: regularly monitor and evaluate at intervals the rate of adoption and impact of pesticidal plants on plants and animal health so as to identify areas that need improvement.
- Extension services: extensionists must be trained on the technicality of pesticidal plants so as to equip them with necessary knowledge to carry the gospel of pesticidal plant usage to farmers.
- Regulatory framework: Nigerian government must establish a regulatory framework that will ensure safe and effective use of pesticidal plants.
- Private sector involvement: private sector such as NGOs and agrochemicals

industries should be encouraged to invest in the formulation, marketing and commercialization of pesticidal plants

- Collaboration and partnership: researchers, extension workers, farmers as well as other stakeholders must collaborate among themselves in order to promote the adoption of pesticidal plants.
- Capacity building: organizing trainings, conferences and seminars where farmers and other stakeholders will be trained on production and formulation and use of pesticidal plants by extensionists.
- Infrastructural development: government of the country need to invest more in infrastructural amenities such as processing plant, storage facility, and accessible road networks that will ensure proper distribution networks which will ensure availability and accessibility of pesticidal plants.
- Policy support: Government at all levels need to develop and implement policies as well as set up regulatory framework that will support the usage of pesticidal plants
- Research and development: conduct extensive research to identify and formulate new pesticidal plants derivatives in order to improve on the efficacy and stability of existing ones.
- Awareness and education: Adequate training in order to educate farmers, extension agents and other stakeholders about the benefits of adopting pesticidal plants.

Future prospects of pesticidal plants adoption

The awareness and use of pesticidal plants in developing countries is still at infancy stage although it is metamorphosizing and growing over the time following reported toxicity of synthetic pesticides in the control of insect pests. However, since various research studies has shown the efficacy of pesticidal plants in the control of insect pests, it will be an aberration not to explore them maximally in agriculture as such research attention of scientists should now be focused on refining more plants through exploration and exploitation of biotechnology of which government need to make available grants to research institutions and capital in form of loan/subsidies to agrochemical firms, entrepreneurs, and marketers in order to encourage entrepreneur to go into formulation of more phyto-pesticide in order to encourage increase in local production.

CONCLUSION

In as much as Pesticidal plants has been proven to be a viable alternative to synthetic pesticides (as pesticide derived from plant source are readily available, economical, harmless and eco-friendly), it will be germane to explore them maximally in the quest for sustainable agriculture (food security), sustainable human health, reduced environmental pollution and bio diversity conservation of beneficial organisms. Scientists/researchers should be focused on formulating, commercializing and adopting recognized and efficacious pesticidal plants as well as refining more plants through exploration and exploitation of biotechnology of which government need to make grants available to research institutions and capital in form of loan/subsidies to farmers, agrochemical firms, entrepreneurs, and marketers in order to encourage entrepreneur to go into formulation and commercialization of this pesticidal plants which will be effective in the management of pests that has developed resistance to synthetic pesticides thereby reducing over dependence on synthetic chemicals which has negative impact on the environment as well as human health due to its toxicity, high residual in crop, non-biodegradability and huge environmental issues that might arise due to its usage.

REFERENCES

Anani, O. A., Mishra, P., Enuneku, A. A., Anani, G. A. and Adetunji, C. O. 2020. 'Effects of toxicant from pesticides on food security: current developments' *In Innovations in Food Technology*. Eds. P. (New York, NY: Springer), 313-321.

Ayilara, M. S., Adeleke, B. S., Babalola, O. O. 2022. Bioprospecting and challenges of plant microbiome research for sustainable agriculture, a review on soybean endophytic bacteria. *Microb. Ecol.* 2022, 1-23. Doi:10.1007/s00248-022-02136-z.

Chandler, D., Bailey, A. S., Tatchell, G. M., Davidson, G., Greaves, J., Grant, W. P. 2011. The development, regulation, and use of biopesticides for integrated pest management Philosophical Transactions of the Royal Society of London. *Biological Sciences* 366(1573): 1987-1998.

Copping, L. G. and Menn, J. J. 2000. Biopesticides: a review of their action, applications and efficacy. *Pest Management Science* 56(8): 651-676.

DAFF (Department of Agriculture, Fisheries and Forestry), 2015. Guidelines on the Data Required for Registration of Biological/Biopesticides Remedies in South Africa. (2015). Available on line: http://www.nda.agric.za/doaDev/side Menu/ActNo36_1947/AIC/Guidelines HYPERLINK "http://www.nda.agric.za/doaDev/side Menu/ActNo36_1947/AIC/Guidelines %20for%20Regisration

Glare, T., Caradus, J., Gelernter, W., Jackson, T., Keyhani,N., Kohl, J., Marrone, P., Morin, L. and Stewart, A. 2012. Have biopesticides come of age? *Trends Biotechnology,* 30(5): 250-258. DOI:10.1016/j.tibtech.2012.01.003

Gupta, S. and Dikshit, A. 2010. Biopesticides: an ecofriendly approach for pest control. *J. Biopesticides.* 3(1): 186-188.

Kandar, P. 2021. Phytochemicals and biopesticides: Development, current challenges and effects on human health and diseases. Journal of Biomedical Research 2 (1): 3-15

Kumar, S. and A. Singh, 2015. Biopesticides: Present status and future prospects. *J. Fertilizers Pesticides,* 6: 1-2. DOI: 10.4172/2471-2728.1000e129

Li, Z., Xiong, J. and Fantke P. 2022. Screening of pesticide distributions in foods of animal origin: a matrix –based approach for biotransfer factor modeling of grazing mammals. *Environ Sci Process Impacts* 24: 609-624. Doi: 10.1039/d1em00454a

Mazid, S., Kalita, J. C. and Rajkhowa, R. C. 2011. A review on the use of biopesticides in insect pest management. *International Journal of Science and Advanced Technology* 1(7): 169-178.

Mishra, J., Tewari, S., Singh, S. and Arora, N. K. 2015. Biopesticides: Where we stand. Plant Microbes Symbiosis: *Applied Facets*, 9:37-75. DOI:10.1007/978-81-322-2068-8

Okwute, S. K. 2012. Plants as potential sources of pesticidal agents: a review. In: Soundarrajan, R. P. (ed), Pesticidez-advances in chemical and botanical pesticides. In Tech: USA. 207-323.

Omoyajowo, K., Njok, K., Amiolemen, S., Ogidan, J., Adenekan, O. and Olaniyan, K. 2018. Assessment of pesticide residue levels in common fruits consumed in Lagos State, Nigeria. *LASU J. Res. Rev. Sci* 56-62.

Onwujiogu, V. C., Abugu, H. O. and Okoye, C. O. 2022. Health risk assessment of pesticide residue in freshly harvested *Vigna subtserranea* (Bambara nut) in Nsukka south eastern Nigeria. *Environ.*

Mont. Assess. 194, 1-5. Doi: 10.1007/s10661-022-10201-w

Prabha, S., Y., Ashwani, A., K. and Yadav A. 2016. Biopesticides- an alternative and eco-friendly source for the control of pests in agricultural crops. *Plant Archives,* 16: 902-906

Varsha, B. and Shahida, I. 2020. Biopesticides: Production, Formulation and Application Systems. *Int Journal of Current Microbio and appl Sci.*ISSN:2319-7706. DOI 10.20546/ijcmas.2020.910.453

Influence of Intercropping Leguminous Crops on Growth and Yield of Cocoyam in Ishiagu

[1]Olusola, O. J.*, [1]Okonta, U., [2]Sanusi, O. O. and [1]Nwoga, J. C.

[1] Department of Crop Production Technology,
[2] Department of Horticulture and Landscape Technology,
Federal College of Agriculture, Ishiagu, Ebonyi State, Nigeria.

ABSTRACT

Intercropping is the simultaneous cultivation of multiple crops, enhances land use efficiency and crop diversification, particularly in regions like southeastern Nigeria. This study evaluated the effects of intercropping Ccocoyam (*Colocasia esculenta*) with leguminous crops (Bambara nut, Ccowpea, Ssoybean, and Ggroundnut) on its growth and yield in Ishiagu, Ebonyi State, during the 2024 cropping season. The experiment design used was randomized complete block design with five treatments (sole cocoyam and cocoyam intercropped with each legume) replicated three times. Cocoyam corms were planted at 1 m × 1 m spacing, with legumes sown at 50 cm × 50 cm. Basal application of poultry manure at 5 t/ha incorporated one week before planting. Growth parameters (plant height and number of leaves) were measured at 6, 9, and 12 weeks after planting, and yield parameters (number and weight of corms and cormels) were assessed at harvest. Data were analyzed using ANOVA, with significant means separated by Tukey's test ($p < 0.05$). Results showed no significant differences ($p > 0.05$) in all growth parameters. Yield parameters indicated significant improvements ($p < 0.05$) in corm and cormel weights, with Ccocoyam + Bambara nut yielding the highest corm weight (3.47 kg) and cormel weight (10.97 kg). These findings suggest that legume intercropping, particularly with Bambara nut, enhances cocoyam yield. This cost-effective, eco-friendly practice offers a sustainable strategy for small-scale farmers to improve cocoyam production and food security.

Key words: Cocoyam, intercropping, leguminous crops, yield

***Corresponding Author:** olusola.olusegun@fcaishiagu.edu.ng

INTRODUCTION

Intercropping involves growing two or more crops simultaneously without a distinct row arrangement, intensifying cropping in spatial dimensions (Lithourgidis *et al.*, 2011). Population growth, pressure on land resources, frequent crop failures due to weather, pests, diseases, and food security needs drive its adoption (Tadesse *et al.*, 2012). Intercropping adds value to cropping systems by increasing productivity, optimizing resource use, and boosting income (Manasa *et al.*, 2018). Intercropping cocoyam with other crops is recommended for regions with high land pressure. Cocoyam, a staple in southeast and south-south Nigeria (Azeez and Madukwe, 2010), is primarily cultivated by small-scale, resource-poor farmers (Onyeka, 2014). These farmers often do not prioritize complementary intercrop systems or specific sowing dates for component crops. Common crop mixtures in these regions include yam, cassava, maize, plantain, and cocoyam in various combinations, with legume-based combinations also reported (Mbah, 2018). Cocoyam (*Colocasia* spp.), a corm-producing herbaceous perennial of the Araceae family, is an important tropical root crop grown purposely for its starchy corms or underground stem and also regarded as one of the most important staple crops globally (Si *et al.*, 2018).

Intercropping legumes with other crops improves soil fertility through nitrogen fixation, increases yields, and enhances resource use efficiency, promoting sustainable agriculture. Nitrogen fixed by legumes benefits companion crops, improving their growth and yield. Legume-based intercropping also fosters beneficial rhizobacterial communities, enhancing soil quality and rhizosphere conditions for better resource uptake (Duchene *et al.*, 2017; Chamkhi *et al.*, 2022).

Therefore, the objective of this study is to evaluate the effects of leguminous crop intercropping on the growth and yield of cocoyam in Ishiagu, Nigeria.

MATERIALS AND METHODS

The research was conducted at the Research and Teaching Farm of the Federal College of Agriculture, Ishiagu, Ebonyi State, during the 2024 cropping season. Ishiagu is located at longitude 07º46'E and latitude 05º45'N, with a mean annual temperature of 29ºC and mean annual rainfall of approximately 1,350 mm. The area lies within the derived savannah vegetation zone of south eastern Nigeria. The region experiences two distinct seasons: a dry season from November to March (occasionally extending to April) and a rainy season from April to October (Nwite *et al.*, 2008).

The experimental design used was randomized complete block design (RCBD) with five treatments replicated three times. Cocoyam (*Colocasia esculenta*) corms were sourced from the National Root Crops Research Institute (NRCRI), Umudike, Abia State, while Bambara nut, soybean, cowpea, and groundnut seeds were obtained from a farm shop in Ishiagu, Ebonyi State.

The experimental site was cleared, ploughed, harrowed, pegged, and divided into three blocks. Beds were prepared using a native hoe, with each plot measuring 2 m × 4 m (8 m²). Each block contained five plots, totalling 15 plots. Cocoyam corms (500 g each) were planted on April 29, 2024, at a spacing of 1 m × 1 m and a depth of 5 cm, with one corm per hole. Leguminous crops were sown at a spacing of 50 cm × 50 cm. Poultry manure was applied basally at 5 t/ha and incorporated into the soil one week before planting.

The treatments were:

T1- Cocoyam sole
T2- Cocoyam + Bambara nut
T3- Cocoyam + Cowpea
T4- Cocoyam + Soybean
T5- Cocoyam + Groundnut

Data were collected on growth parameters (plant height and number of leaves) at 6, 9, and 12 weeks after planting (WAP) and yield parameters (number and weight of corms and cormels) at harvest. Data were analyzed using analysis of variance (ANOVA) with Minitab software (Version 17). Significant treatment means were separated using Tukey's test at a 5% probability level.

RESULTS

No significant differences ($p > 0.05$) were observed among treatments for growth parameters at any sampling interval (Tables 1–2). At 6 WAP, cocoyam + cowpea plots recorded the highest mean plant height (51.7 cm), followed by cocoyam + bambara nut (49.34 cm), while cocoyam + groundnut had the lowest (41.10 cm). At 9 WAP, cocoyam + bambara nut plots had the highest plant height (93.60 cm), while sole cocoyam plots had the lowest (77.70 cm). At 12 WAP, cocoyam + bambara nut plots recorded the highest plant height (122.10 cm), followed by cocoyam + soybean (105.70 cm), with cocoyam + groundnut having the lowest (93.87 cm).

For the number of leaves (Table 2), no significant differences ($p > 0.05$) were observed. At 6 WAP, all treatments except cocoyam + soybean recorded (3) leaves, a mean of 4 leaves were recorded in other treatments. At 9 and 12 WAP, all treatments produced 6 and 8 leaves, respectively, with no significant differences.

For yield parameters (Table 3), no significant differences ($p > 0.05$) were observed for the number of corms and cormels. Cocoyam + bambara nut plots produced the highest number of corms (10.67), followed by cocoyam + cowpea (9.67), while sole cocoyam and cocoyam + soybean had the lowest (8.00). Corm weight was significantly influenced ($p \leq 0.05$), with cocoyam + bambara nut producing the highest mean weight (3.47 kg), followed by cocoyam + soybean (2.17 kg), and cocoyam + groundnut the lowest (1.70 kg). For cormels, cocoyam + bambara nut plots recorded the highest number (199.00), followed by cocoyam + soybean (128.67), with cocoyam + groundnut the lowest (97.67). Cormel weight showed significant differences ($p \leq 0.05$), with cocoyam + bambara nut producing the highest weight (10.97 kg), while cocoyam + groundnut had the lowest (4.20 kg).

Table 1: Effect of leguminous crops intercropped on plant heights of cocoyam

Treatments	Weeks after planting		
	6	9	12
Cocoyam sole	43.80a	77.70a	105.43a
Cocoyam + Bambara nut	49.34a	93.60a	122.10a
Cocoyam + Cowpea	51.70a	82.33a	97.92a
Cocoyam + Soya bean	41.87a	82.37a	105.70a
Cocoyam + Groundnut	41.10a	81.10a	93.87a
Standard Error	3.02	3.06	4.07

Means in the same column with different letters are significantly different using Tukey at ($p \leq 0.05$)

Table 2: Effect of leguminous crops intercropped on number of leaves of cocoyam

Treatments	Weeks after Planting		
	6	9	12
Cocoyam sole	4.00a	6.00a	8.00a
Cocoyam + Bambara nut	4.00a	6.00a	8.00a
Cocoyam + Cowpea	4.00a	6.00a	8.00a
Cocoyam + Soya bean	3.00a	6.00a	8.00a
Cocoyam + Groundnut	4.00a	6.00a	8.00a
Standard Error	0.21	0.17	0.17

Means in the same column with different letters are significantly different using Tukey at ($p \leq 0.05$)

Table 3: Effect of leguminous crops intercropped on yield of Cocoyam at harvest

Treatments	Number of Corms	Weights of Corm (kg)	Number of Cormels	Weights of Cormels (kg)
Cocoyam sole	8.00a	1.80a	128.00a	5.93ab
Cocoyam + Bambara nut	10.67a	3.47a	199.00a	10.97a
Cocoyam + Cowpea	9.67a	1.97a	119.33a	5.00ab
Cocoyam + Soya bean	8.00a	2.17a	128.67a	6.33ab
Cocoyam + Groundnut	9.00a	1.70a	97.67a	4.20b

Means in the same column with different letters are significantly different using Tukey at ($p \leq 0.05$)

DISCUSSION

Intercropping cocoyam with leguminous crops (Bambara nut, cowpea, soybean, and groundnut) enhanced cocoyam growth and yield in Ishiagu, likely due to nitrogen fixation by legumes, which directly influences growth parameters. This aligns with findings by Egbe and Idoko (2009) and Ossom *et al.* (2009), who reported that crop growth in intercrops varies with component crop populations and interactions. Hernani *et al.* (2018) noted that intercropping crops with complementary traits optimizes light, nutrient, and land use, benefiting the cropping system. Cocoyam intercropped with bambara nut consistently showed superior yield performance and good companion crops, suggesting that legume intercropping can enhance cocoyam yields without much reliance on organic or inorganic fertilizers. This supports Tilman *et al.* (2011), who highlighted that intercropping with legumes mitigates nutrient limitations and boosts yields cost-effectively. Similarly, Luo *et al.* (2016) emphasized that intercropping systems promote sustainable agricultural development.

CONCLUSION

Intercropping cocoyam with leguminous crops is an effective, cost-efficient, and eco-friendly strategy to enhance crop growth and yield. This practice reduces input and management costs, addressing challenges faced by cocoyam farmers. Adopting legume-based intercropping can support sustainable agriculture and improve food security in resource-constrained regions.

REFERENCES

Azeez, A. A. and Madukwe, O. M. 2010. Cocoyam production and economic status of farming households in Abia State South-East Nigeria. *Journal of Agriculture and Soil Science* 6: 83-86.

Chamkhi, I., Cheto, S., Geistlinger, J., Zeroual, Y., Kouisni, L. and Bargaz, A. 2022. Legume-based intercropping systems promote beneficial rhizobacterial community and crop yield under stressing conditions. *Ind. Crops Prod.* 183: 114985.doi: 10.1016/j.indcrop.2022.114958

Duchene, O., Vian, J. F. and Celette, F. 2017. Intercropping with legume for agroecological cropping systems: Complementarity and facilitation processes and the importance of soil microorganisms. A review. *Agric. Ecosyst. Environ.* 240: 148–161.

Egbe, O. M. and Idoko, J. A. 2009. Agronomic assessment of some sweet-potato varieties for intercropping with pigeonpea in Southern Guinea Savanna of Nigeria. *Journal of Tropical Agriculture, Food, Environment and Extension* 8 (2): 74-83.

Hernani, L. C., de Souza L. C. F. and Ceccon, G. 2018. Consorciação de culturas. Agência Embrapa de Informação Tecnológica, Embrapa. http://www.agencia.cnptia.embrapa.br/gestor/sistema_plantio_direto/arvore/C ONT000fx4zsnb y02wyiv80u5vcsvyqcqraq.htm

Lithourgidis, A. S., Vlachostergios, D. N., Dordas, C. A. and Damalas, C. A. 2011. Dry matter yield, nitrogen content, and competition in pea–cereal intercropping systems. *Eur. J. Agron.* 34: 287–294.

Luo, W., Tadesse Tilahun, M. L. and Alemayehu A. 2016. Role of maize (*Zea mays* L.)-fababean (*Vicia faba* L.) intercropping planting pattern productivity and nitrogen use efficiency of maize in northwestern Ethiopia highlands. Int. Research *Journal of Agricultural Science and Soil Science* 2(3): 102-112.

Manasa, P., Maitra, S. and Reddy, M. D. 2018. Effect of summer maize-legume intercropping system on growth, productivity and competitive ability of crops. *Int. J. Manag. Technol. Eng.* 8: 2871–2875.

Mbah, E. U. 2018. Sequential cropping effects of vegetable cowpea on cassava in cassava cowpea intercrop, Umudike, Southern Nigeria. *Journal of Agronomy* 17: 123 – 135.

Nwite, J. C., Igwe C. A. and Wakatsuki, T. 2008. Evaluation of sawah rice management system in an inland valley in southeastern Nigeria I: soil chemical properties and rice yield. *Paddy water Environ.*, 6: 229-307.

Onyeka, J. 2014. Status of cocoyam (*Colocasia esculenta* and *Xanthosoma* spp.) in west and central Africa: production, household importance and the threat from leaf blight. Lima (Peru). CGIAR Research Program on Roots, Tubers and Bananas (RTB). Available at: www.rtb.cgiar.org

Ossom, E. M., Kuhlase, L. M. and Rhykerd, R. L. 2009. Effects of plant population on yield components and yield of intercropped sweetpotato [*Ipomoea batatas* (L.) Lam.] and groundnut (*Arachis hypogaea L.). AmericanEurasian Journal of Agronomy 2(1): 01-06.*

Tadesse, T., Liben, M. and Asefa, A. 2012. Role of maize (*Zea mays* L.)-faba bean (*Vicia faba* L.) intercropping plant pattern on productivity and nitrogen use efficiency of maize in northwestern Ethiopia highlands. *International Research Journal of Agricultural Science and Soil Science*, 2(3): 102-112.

Si, H., Zhang, N., Tang, X., Yang, J., Wen, Y., Wang L. and Zhou, X. 2018. Transgenic research in tuber and roots crops: A review. *Genetic Engineering of Horticultural Crops*, 225-248

Tilman, D., Balzer, C., Hill, J. and Befort, B. L. (2011). Global food demand and the sustainable intensification of agriculture. *Proceedings of the national academy of sciences*, 108(50): 20260-20264.

Assessment of Genetic Variability in Cucumber (*Cucumis sativus* l.) Genotypes for Yield improvement

Egbewale A. A., Otusanya G. O., Aderinto, O. and Sobowale O. O.

Department of Plant Breeding and Seed Technology, Federal University of Agriculture, Abeokuta

ABSTRACT

Knowledge of genetic variability in Cucumber which is a vital crop is needed for effective yield improvement, hence, the need to carry out this study. Eight cucumber genotypes were evaluated on the field of Directorate of Farms, Federal University of Agriculture, Abeokuta in a Randomized Complete Block Design (RCBD) with three replicates. Agronomic traits, including internode distance, fruit dimensions, plant height, and branch length, were measured. Data collected were subjected to Analysis of Variance (ANOVA), significant means were separated using Least Significance Difference (LSD), Principal Component Analysis (PCA) and Genetic parameters were estimated. Significant genotypic variability was observed for fruit diameter, fruit length, internode distance, and branch length. Principal Component Analysis (PCA) revealed that 85% of total variation was explained by three components, with fruit traits and vegetative growth parameters contributing most. High heritability (92%) and genetic advance (5.66) for fruit diameter indicated additive gene action controlling this trait. Genotype CU-GM 30 exhibited superior performance across all traits measured, making it an ideal parent for hybridization in cucumber yield improvement programme.

Key words: Additive gene action, genetic advance, genotypic variability, heritability, hybridization,

***Corresponding author:** igegbemi@gmail.com

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is one of the important Asiatic species and member of the Cucurbitaceae family having chromosome number 2n = 14 which has 120 genera and more than 800 species (Jeffrey, 1980). Cucumber originated in India from its wild progenitor *Cucumis sativus* var. hardwickii R., which is still found in southern foothills of Himalayas (Sebastian, 2010). One hundred gram of edible cucumber fruits contain 96 g water, 0.6 g protein, 0.1 g fat, 2.2 g carbohydrate, 45 International unit Vitamin A, 0.03 mg Vitamin B_1, 0.02 mg Vitamin B_2, 0.3 mg Niacin, 12 mg Vitamin C, 12 mg Calcium, 0.3 mg Iron, 15 mg Magnesium and 24mg phosphorus (Alcazar and Gulick, 1983). It is well known for its economic importance as food plant, primarily cultivated for tender fruits, which are used as salad. The fruits are highly useful in both high and low blood pressure alleviation because of its high content of potassium (Kashif *et al.* 2008). Fruits are also used as an astringent and antipyretic and the seed oil of cucumber is highly valuable for development of brain (Robinson and Decker-Walters, 1999).

In a breeding program to improve agronomic characters, genetic variability is an essential part of through which the gene pool of crops can be broadened (Ahmad *et al.,* 2011). The selection is effective in the presence of genetic variability between the individuals in a population (Vashistha *et al.,* 2013). The initial step for any crop advancement plan and acquiring suitable selection techniques is the critical investigation of genetic variability existing in the germplasm of a crop and its analysis (Sravanti *et al.*, 2017). Parameters like the genotypic coefficient of variation and phenotypic coefficients of variation help to find out the amount of variability present in given characteristics (Sesay *et al.*, 2016). Heritability and genetic advance of the individual trait are the major factors determining the efficiency by which the genotypic variability can be utilized through selection (Bilgin *et al.*, 2010). Heritability gives knowledge about how much a certain morphogenetic feature can be transferred to future generations (Bello *et al.*, 2012), while, Genetic advance expresses the degree of the gain secured in a character under certain selection pressure. Estimation of both heritability and genetic advance is better to determine the gain under selection as compared to an estimation of heritability only (Johnson *et al.*, 1955). Both heritability and genetic advance would be more applicable and helpful to formulate selection procedures (Jaiswal *et al.*, 2019). Thus, this study was carried out to evaluate genetic variability in cucumber genotypes, identify yield contributing traits, and estimate heritability and genetic advance for agronomic traits.

MATERIALS AND METHODS

Eight cucumber genotypes (seven hybrids and one local variety) were sourced from reputable seed company (Table 1). The seven hybrids were sourced from KUCH-99 Agriculture and seeds limited located in Lagos, Nigeria, and the local commercial variety used as check was sourced from Diekola farms. The experiment was carried out at the Teaching and Research farm of the Federal University of Agriculture, Abeokuta (FUNAAB) located at Latitude 7° 23'N and Longitude 3° 44'E, Ogun State, South west, Nigeria. The land was cleared, harrowed and ploughed to loosen the soil for ease of cultivation, after which the field was mapped out with pegs, ropes and measuring tape. The research was carried out on randomized complete block design replicated three times. The cucumber seeds were planted by drilling into the prepared field plots at sowing depth of 2 cm and at an intra-spacing of 0.6 m and interspacing of 1 m with two seeds per hole, which were later thinned to one plant per stand at 2 weeks after planting (WAP). Weeding was done with the aid of hoe at two weeks interval. There was no fertilizer application all through the experiment. At maturity (7-9 WAP) matured cucumber fruits were harvested manually with the use of sharpened knife. Five plants per plot were chosen randomly and were tagged in each plot to collect data. Then, data of different traits were recorded from those selected plants. The plant height, distance between internodes, length of branches, shoots diameter, leaf length, leaf breadth, fruit diameter, fruit length, fruit number per node, 1000 seeds weight were taken. All data collected in the experiment were subjected to analysis of Variance (ANOVA), using Statistically Analysis System software package (SAS vs 9.1). The differences among treatment means were separated using least significant difference (LSD) at 5% probability level. Genotypic variation (σ^2g), phenotypic variation (σ^2p) and environmental variation (σ^2e) were estimated according to the formula of Mehdi and Khan (2009) and Kumar *et al.* (2008). Heritability in broad sense and Genetic advance were also estimated according to Burton and De Vane (1953) and Allard (1960). Principal component analysis (PCA) was calculated according to Golabadi *et al.* (2019).

RESULTS

Analysis of variance for yield and related traits of cucumber genotypes

The result showed highly significant differences ($p \leq 0.01$) in distance between internode, fruit diameter, fruit length, 1000 seeds weight, and length of branches (Table 2). Highly significant difference was observed in leaf length, shoot diameter, and fruit diameter with respect to block effect.

Table 1. Genotypes used for the study with their sources

Genotype	Source
OBONG KING	KUCH-99 d
SMART	KUCH-99 d
CU-PM 20	KUCH-99 d
CU-MM 25	KUCH-99 d
CU-20117	KUCH-99 d
CU-GM 30	KUCH-99 d
AFRICAN GIANT	KUCH-99
DARINA	Diekola farms

Source: Agriculture and Seeds Limited

Table 2. Analysis of variance for yield and yield related traits of cucumber genotypes

Character	Source of variation		
	Genotype (df = 7)	Block (df = 2)	Error (df = 14)
DBI (cm)	4.59*	2.13	1.31
LB (cm)	6.08	4.78	3.05
LL (cm)	5.48	22.74**	3.55
SD (mm)	3.80	8.05*	2.15
PH (cm)	862.77	455.88	708.44
FD (cm)	25.36**	5.15**	0.72
FL (cm)	25.57**	14.88	5.4
FNPN	0.90	0.75	0.35
1000-SW (g)	82.45**	32.92	13.7
LOB (cm)	884.85**	557.59	203.95

Significance codes according to ANOVA F-test (P value): **0.01(highly significant); *0.05 (significant).
S.V: Source of Variation; Df: Degree of Freedom; DBI: distance between internode; LB: leaf breadth; LL: leaf length; SD: shoot diameter; PH: plant height; FD: fruit diameter; FL: fruit length; FNPN: fruit no per node; 1000 SW: 1000 seed weight; LOB: length of branches.

Mean performance of eight cucumber genotypes evaluated for yield and yield related traits

Table 3 shows the mean performance of eight genotypes of cucumber evaluated for agronomic characters. CU-GM 30 outperformed other genotypes in distance between internodes recording the highest with the mean of 9.22 cm, while SMART recorded the lowest with the mean of 5.06 cm. CU-GM 30 also recorded the highest plant height (117.67 cm) while OBONG KING and SMART were short with the mean of 75.80 cm and 60.53 cm respectively. CU-GM 30 had the highest value for leaf length (14.34 cm) while CU-MM 25 and SMART had the lowest value for leaf length with the mean of 10.69 cm and 9.99 cm respectively. SMART recorded the highest value for fruit numbers per node with mean of 2.70 while CU-20117 has the lowest value for fruit numbers per node with mean of 1.00. The highest mean value for 1000 seeds weight was recorded in CU-PM 20 (23.04 g) while CU-20117 and AFRICAN GIANT recorded the lowest 1000 seeds weight of 11.02 g and 10.36 g respectively.

Principal component analysis for each character measured

The first three principal components with Eigen values greater than one accounted for 85% of the total variation among the genotypes for 10 characters and presented in Table 4. The first principal component (PC1) had an Eigen value of 5.44 and accounted for 54% of genetic variability among the cucumber genotypes. This variability was positively and highly associated with leaf breadth, shoot diameter, leaf length, plant height, fruit length, and distance between internode. The second component axes (PC2) accounted for 20% of the total variability among tested cucumber genotypes, which made 75% for the total variability of PC1 and PC2. PC2 had Eigen value of traced from variation in length of branches (0.20), shoot diameter (0.04), fruit diameter (0.27), fruit no per node (0.64), and 1000 seeds weight (0.57). Leaf breadth (-0.23), leaf length (-0.41), shoot diameter (-0.15), plant height (-0.10), fruit no per node (-0.16), and 1000 seeds weight (-0.07) were the main negative loading factors in the third principal component with an Eigen value of 1.04 and accounted for 10 % of the total genetic variability among genotypes.

Table 3. Mean performance of eight cucumber genotypes evaluated for yield and yield related traits

Genotype	DBI (cm)	LB (cm)	LL (cm)	SD (mm)	PH (cm)	FD (cm)	FL (cm)	FNPN	1000 SW (g)	LOB (cm)
CU-GM 30	9.22[a]	15.47[a]	14.34[a]	10.73[a]	117.67[a]	21.75[a]	24.00[a]	1.50[bc]	22.93[ab]	76.96[a]
CU-20117	8.00[ab]	12.73[ab]	11.83[ab]	8.00[b]	85.15[ab]	12.17[e]	21.17[ab]	1.00[c]	11.02[d]	63.58[ab]
DARINA	7.14[b]	13.42[ab]	13.07[ab]	8.12[b]	78.67[ab]	19.53[b]	22.03[ab]	1.60[bc]	19.24[abc]	45.20[bc]
CU-PM 20	6.65[bc]	13.63[ab]	12.13[ab]	8.83[ab]	96.40[ab]	16.76[c]	16.49[cd]	2.33[ab]	23.04[a]	45.83[bc]
AFRICAN GIANT	6.53[bc]	12.03[b]	11.73[ab]	7.43[b]	75.93[ab]	14.58[d]	18.41[bcd]	1.50[bc]	10.36[d]	24.00[c]
OBONG KING	6.48[bc]	12.47[ab]	11.36[ab]	8.41[ab]	75.80[ab]	16.82[c]	19.61[bc]	1.46[bc]	14.60[cd]	48.25[bc]
CU-MM 25	6.36[bc]	11.75[b]	10.69[b]	7.99[b]	80.33[ab]	17.13[c]	18.70[bcd]	1.47[bc]	16.49[bcd]	41.50[bc]
SMART	5.06[c]	10.76[b]	9.99[b]	7.00[b]	60.53[b]	15.95[cd]	15.10[d]	2.70[a]	22.67[ab]	60.25[ab]

Means with the same alphabets are not significantly different from each other.
DBI: Distance between internode; LB: Leaf breadth; LL: Leaf length; SD: Shoot diameter; PH: Plant height; FD: Fruit diameter; FL: Fruit length; FNPN: Fruit no per node; 1000 SW: 1000 Seed weight; LOB: Length of branches.

Table 4. Principal Component Analysis for yield and yield related traits of cucumber genotypes

Character	Prin1	Prin2	Prin3
Distance between internode (cm)	0.36	-0.25	0.05
Leaf breadth (cm)	0.40	-0.07	-0.23
Leaf length (cm)	0.36	-0.13	-0.41
Length of branches (cm)	0.21	0.20	0.70
Shoot diameter (mm)	0.40	0.04	-0.15
Plant height (cm)	0.38	-0.06	-0.10
Fruit diameter (cm)	0.27	0.27	0.20
Fruit length (cm)	0.31	-0.25	0.44
Fruit no per node	-0.00	0.64	-0.16
1000 seeds weight (g)	0.23	0.57	-0.07
Eigenvalue	5.44	2.04	1.04
Proportion	0.54	0.20	0.10
Cumulative (%)	54.00	75.00	85.00

Genetic parameters for agronomic characters

Phenotypic and genotypic variances were estimated for all the characters measured (Table 5). The phenotypic variance of the characters under study were divided into heritable (genotypic variance) and non-heritable (environmental variance) components. The magnitude of environmental variances was higher than their corresponding genotypic variances for most characters, except for leaf length, fruit diameter, fruit length.

The environmental variance ranged from 0.72 (fruit diameter) to 708.44 (plant height). The highest estimate of the environmental variance was recorded for plant height (708.44) followed by length of branches (203.95), and fruit length (5.40). The genotypic variance ranged from 0.55 (shoot diameter) to 226.97 (length of branches). Heritability in broad sense was estimated for all the characters. Heritability estimates varied from 7% (plant height) to 92% (fruit diameter).

Table 5. Genetic parameters for yield and yield related trait of cucumber genotypes

Character	σ^2p	σ^2g	σ^2e	H^2bs (%)	GA
Internode length (cm)	2.40	1.09	1.31	46	1.45
Leaf breadth (cm)	4.06	1.01	3.05	25	1.03
Leaf length (cm)	4.19	0.64	3.55	15	0.65
Length of branches (cm)	430.92	226.97	203.95	53	22.52
Shoot diameter (mm)	2.70	0.55	2.15	20	0.69
Plant height (cm)	759.88	51.44	708.44	7	3.84
Fruit diameter (cm)	8.94	8.21	0.72	92	5.66
Fruit length (cm)	12.12	6.72	5.40	56	3.98

σ^2p: phenotypic variance; σ^2g: genotypic variance; σ^2e: environmental variance; H^2bs: broad-sense heritability; GA: genetic advance.

High estimates of heritability were observed for the characters like fruit diameter (92%) followed by fruit length (56%) and length of branches (53%). Expected genetic advance ranged from 0.65 (leaf length) to 22.52 (length of branches). The highest estimate of expected genetic advance was recorded for length of branches (22.52), followed by fruit diameter (5.66).

DISCUSSION

The study showed significant genetic variability among cucumber genotypes for key contributing significantly, supporting the report of Vashistha *et al.* (2013) regarding effective selection. The high heritability (92%) coupled with substantial genetic advance (5.66) for fruit diameter indicates predominant additive gene action, suggesting excellent potential for selection efficiency as emphasized by Jaiswal *et al.* (2019). Genotype CU-GM 30 showed superior performance across multiple traits, positioning it as an ideal parent for hybridization programs, supporting the findings of Sravanti *et al.* (2017) on critical investigation of genetic variability for identifying suitable parents for yield improvement programme.

CONCLUSION

Significant genetic variability exists among cucumber genotypes, with fruit diameter, branch length, and internode distance being key heritable traits. CU-GM 30 and CU-PM 20 are recommended for breeding programmes targeting yield improvement and stress tolerance. Future studies should integrate molecular markers to validate phenotypic observations.

Agronomic traits, particularly internode distance, fruit diameter, fruit length, 1000 seed weight, and branch length. he variability in CU-PM 20 for 1000 seed weight and SMART for fruit number per node provides diverse genetic resources for trait-specific breeding objectives, aligning with the assertion of Ahmad *et al.* (2011) regarding the importance of genetic variability for broadening crop gene pools. Principal component analysis revealed that 85% of total variation was explained by three components, with vegetative growth parameters and fruit characteristics.

REFERENCES

Ahmad, S. Q., Khan, S., Ghaffar, M. and Ahmad, F. 2011. Genetic diversity analysis for yield and other parameters in maize (*Zea mays* L.) genotypes. *Asian Journal of Agricultural Sciences*, 3(5): 385-388.

Allard R. W. 1960. Principles of Plant Breeding. John Wiley and Sons Inc., New York. Pp 48.

Alcazar E. J. T and Gulick P. J. 1983. Genetic resources of Cucurbitaceae-A Global report, Rome, International Board for Plant Genetic Resources, Rome, Pp 101.

Bello, O. B., Ige, S. A., Azeez, M. A., Afolabi, M. S., Abdulmaliq S. Y. and Mahamood, J. 2012. Heritability and genetic advance for grain yield and its component characters in maize (*Zea mays* L.). *International Journal of Plant Research*, 2(5): 138-145.

Bilgin, O., Korkut, K. Z., Baser, I., Dalioglu O., Ozturk, I., Kahraman, T. and Balkan, A. 2010. Variation and heritability for some semolina characteristics and grain yield and their relations in durum wheat (*Triticum durum* Desf.). *World Journal of Agricultural Science*, 6(2): 301-308.

Burton G. M and De Vane E. H. 1953. Estimating heritability in tall fescue (*Festuca arundineacea*) from replicated clonal material. *Agronomy Journal*, 45: 478-81.

Golabadi, M., Mehrdad K., Shirani M. and Atefeh N. 2019. Comparison of Some Economic Traits in Greenhouse

Cucumber (*Cucumis sativus* L.) Hybrids. *Research on Crop Ecophysiology*, 14(2): 119-124.

Jaiswal, P., Banshidhar, S., Agrahari, R. and Singh R. 2019. Estimation of genetic parameters for yield related traits and grain zinc concentration in bio-fortified inbred lines of maize (*Zea mays* L.). *The Pharma Innovation Journal*, 8(3): 87-91.

Jeffrey C. 1980. A review of the Cucurbitaceae. *Botanical Journal of the Linnean Society*, 81: 233–247

Johnson, H. W., Robinson, H. F. and Comstock R. 1955. Estimates of genetic and environmental variability in soybean. *Agronomy Journal*, 47: 314-318.

Kashif W., Kamran Q. M, Jilani M. S. 2008. Effect of different nitrogen levels on growth and yield of cucumber (*Cucumis sativus* L.). *Journal of Agricultural Research*, 46 (3): 259–266.

Kumar, A., Kumar, S. and Pal, A. K. 2008. Genetic variability and characters association for fruit yield and yield traits in cucumber. *Indian Journal of Horticulture*, 65(4): 423-8.

Mehdi M, and Khan F. A. S. 2009 Variability and character association analysis in cucumber germplasm. *Journal of Agriculture and Biological Research*, 25 (2): 87-91.

Robinson R. W. and Decker-Walters D. S. 1997. Cucurbits: Volume 6 of Agricultural series, issue of Crop Production in Horticultural Science, *CAB International* Pp 226.

Sesay, S., Ojo, D. K., Ariyo, O. J. and Meseka, S. 2016. Genetic variability, heritability and genetic advance studies in top-cross and three-way cross maize (*Zea mays* L.) hybrids. *Maydica*, 61(2): M12, 1-7.

Sravanti, K., Devi, I. S., Sudarshan, M. R. and Supriya, S. 2017. Evaluation of maize genotypes (*Zea mays* L.) for variability, heritability and genetic advance. *International Journal of Current Microbiology and Applied Sciences*, 6(10): 2227-2232.

Vashistha, A., Dixit, N. N., Dipika, S., Sharma, S. K. and Marker, S. 2013. Studies on heritability and genetic advance estimates in maize genotypes. *Bioscience Discovery*, 4(2): 65-168.

Vertical Farming: Key to a Sustainable Food Production in Nigeria

[1]Leddi K. W. and [2]Mshelia, J. S.

[1] Department of Agronomy, Faculty of Agriculture, Federal University of Kashere, Gombe State.
[2] Department of Crop Science, Federal University of Agriculture Mubi, PMB 2025, Mubi, Adamawa State.

ABSTRACT

Nigeria faces significant challenges in food production, with a rapidly growing population and limited arable land. Vertical farming is emerging as a transformative solution to address food security challenges in Nigeria's rapidly urbanizing regions. By cultivating crops in vertically stacked layers within controlled environments, this innovative approach maximizes space utilization and offers a sustainable alternative to traditional agriculture. The rapid growth of populations in Nigerian urban centers produces vital food security problems due to insufficient arable land resources. Vertical farming presents a viable solution by enabling year-round cultivation of fresh produce within city environments. The practice lowers agricultural dependence in rural areas and allows distribution costs to decrease. The method provides steady food availability and produces higher quality nutritional content for obtainable produce. This paper explores critically the theory of vertical farming in addressing the issues that exist in today's food system, the potential of vertical farming to address Nigeria's food security challenges, examining the benefits of this innovative approach, including increased crop yields, reduced water usage, and improving accessibility and reducing environmental impact. We discuss the current state of vertical farming in Nigeria, highlighting successful initiatives and identifying areas for further development. Our analysis suggest that vertical farming can play a key role in Nigeria's sustainable food production, and we propose policy recommendations to support the growth of vertical farming in Nigeria.

Key words: Food security, food systems, Nigeria, vertical farming (VF), sustainable food production

***Correspondent email**: kalifaleddi@gmail.com

INTRODUCTION

Vertical farming is the exercise of producing food in vertically stacked layers, which are commonly integrated into other structures like skyscrapers, reallocated warehouses or shipping containers rather than farming on field or a protected greenhouse (Deepika and Anureet, 2021). This indoor modern farming technique is done by using Controlled Environment Agriculture (CEA) technology as shown in Plate 1. In vertical farming, there is artificial control of temperature, light, humidity, and gases, which is close to greenhouses where natural sunlight is extended through metal reflectors and artificial lighting. Vertical farms' key purpose is to lower the overall resources used and also to reduce agriculture's carbon footprint.

Vertical farming is considered as a modern tool for feeding large world population by year 2050. The idea of vertical farming is not entirely new. Examples of it can be found dating back to the ancient era in the Hanging Gardens of Babylon, one of Philon's Seven Wonders of the Ancient World, built around 600 BC. In 1915, Gilbert Ellis Bailey coined the term "vertical farming" and wrote a book titled "Vertical Farming". He argued that farming hydroponically in a controlled vertical environment would provide economic and environmental benefits. In the early 1930s, William Frederick Gericke pioneered hydroponics at the University of California at Berkley.

Plate 1: Indoor vertical farming
Source: (Deepika and Anureet, 2021)

METHODOLOGY

Studies on the topic come in multiple forms, including professional reports, academic papers and articles, as demonstrated in this paper's references. This paper combines various sources to endeavour to answer the above questions. In addition, this paper examines a wide range of literature reviews related to vertical farming. It also involved reviews on technologies and current cultivation techniques to the future of farming technology.

IMPORTANT FINDINGS OF THE RESEARCH

Why Vertical Farming

1. **Food Security**: The World Food Summit in 1996 defined food security as occurring if all people continuously, physically, socially, and economically have access to adequate/sufficient, nutritious, and safe food, that meets their food needs and food choices for an active and healthy life (Sumsion *et al.,* 2023). Several experts agree that food security contains at least two main elements, namely food availability and people's accessibility to that food. Availability and sufficiency of food include the quantity and quality of food so that each individual can meet the standard calorie and energy needs to carry out economic activities and daily life. Starting from 0.52 ha per person, the arable land worldwide is constantly shrinking in area, which is a matter of concern (Thokchom *et al.*, 2021). As the world's population will increase by 40%, exceeding 9 billion people by the year 2050, and as predicted we would need 70% more food to meet the demands as shown in Figure 1

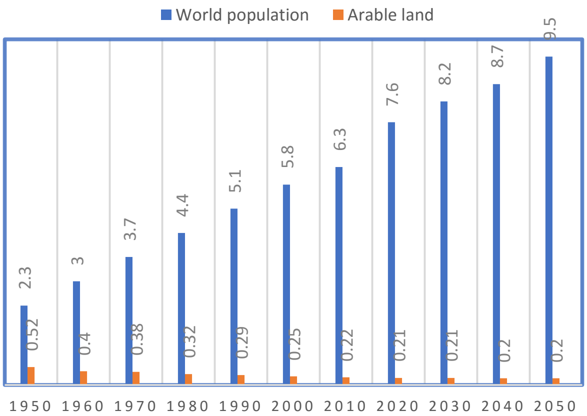


Figure 1: World population (billions) versus arable land (ha per person) 1950 – 2050 Source: (Gupta, et *al.,* 2021).

2. **Climate Change**: Climate change will destroy large tracts of arable land, making them useless for farming. In traditional farming, farmers use fossil fuel to run machinery, emit Green House Gas (GHG), which leads to climate change, a major issue to deal with. "Food miles" refers to the distance crops travel to reach central urban populations. Food travels 1500 km averagely from farm field to dinner table. It requires transportation, which emits carbon dioxide. Vertical farming somehow reduces use of machinery and food miles will not become an issue as this farming technique

is done in between urban populations (Despommier, 2014).

3. Ecosystem: According to Despommier, (2013), "Farming has upset more ecological processes than anything else it is the most destructive process on earth". Indoor vertical farming through biodiversity restoration can reduce the agricultural impact on ecosystems and less negative influences of climate change. If cities implement vertical farms, which consume 10% of ground area, then it might help in CO_2 emission reduction, which might be enough to develop better technological innovations for improving the condition of the biosphere long-term. By elimination of fertilizer runoff, coastal and river water could be restored, and marine life could increase. Advantages and disadvantages of vertical farming are presented in Table 1.

Table 1: Advantages and disadvantages of vertical farming

Advantage	Disadvantage
Provide proposals to deal with future food problems.	Expensive to build and high installation costs.
Allows crops to grow year-round	Pollination would be costly and difficult.
Water can be used efficiently.	Too much dependency in technology.
Less exposure to chemicals and diseases.	Involve high-cost technical labour.
Not affected by unfavourable climatic conditions	Requires large amounts of electricity.
Environment friendly. Leaves a smaller footprint	Significant maintenance efforts.

Source: (Deepika and Anureet, 2021)

The common goal of agriculture is increasing the yield in a sustainable way. Table 2 shows the estimated yield of a vertical farm compared to greenhouse farming for the different crops.

Nigeria can, through the application of vertical farming, improve its agricultural production, create employment opportunities in urban

Table 2: Estimated yield of a vertical farm compared to greenhouse

Crops	Yield in vertical farming (tons/ha)	Yield in green house (tons/ha)
Carrot	58	30
Potatoes	150	28
Tomatoes	155	45
Lettuce	37	25
Pepper	133	30
Average	106.6	31.6

Source: (Ronald, 2020)

Potentials of vertical farming

Societies via the value chain, and consequently foster economic growth. Vertical farming offers many potentials in agricultural land space if fully utilized, the potentials of vertical farming include:

- ✓ All year-round production
- ✓ Optimization of plant growing conditions
- ✓ Create employment opportunities in urban areas
- ✓ Enhances soil fertility and resource conservation
- ✓ Transportation costs can be eliminated due to proximity to the consumers

CONCLUSION

Vertical farming is the future of agriculture. As population is increasing day by day and it is estimated by 2050, the population will touch almost 10 billion but on the other side arable land is decreasing due to urbanization, industrialization and many more things, which are occupying agricultural land. It is high time to switch to modern Vertical Farming to practice a more sustainable form of agriculture. Currently, it is not so popular and advanced and has some limitations over benefits but near future, it will be normalized as traditional agriculture. "We live vertically, so why can't we farm vertically?" Vertical farming has emerged as a critical solution for addressing food sustainability challenges in urban areas, particularly as the global urban population continues to rise. Vertical farming is a transformative approach that addresses the pressing issue of food security. By harnessing innovative technologies, optimizing resource utilization, and promoting local food production, vertical faming offers a sustainable solution to feeding the world's population. Vertical farming has the potential to transform the food production landscape, enhancing food security by increasing yields, improving accessibility and reducing environmental impact.

REFERENCES

Deepika, N. and Anureet, K. S. 2021. Vertical Farming - An Approach to Sustainable Agriculture. *International Journal for Research in Applied Science & Engineering Technology (IJRASET)* ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429 Volume **9**.

Despommier, D. 2013. Farming up the city: the rise of urban vertical farms. *Trends Biotechnol* 31(7): 388-389.

Despommier, D. 2014. Vertical farms in horticulture. Book Encyclopedia of Food and Agricultural Ethics; Thompson, PB, Kaplan, DM, Eds: 1860

Gupta, P., Kusuma, P., Pattison, P. M. and Bugbee, B. 2021. Impact of climate change and water quality degradation on food security and agriculture. Water Conservation in the Era of Global Climate Change, Elsevier: 1-22.

Ronald, J. 2020. Vertical Farming: Concept for Food Security. A Term Paper Submitted to the Dr. Adornado C. Vergara of College of Engineering, Nueva Vizcaya State University, Bayombong, Nueva Vizcaya in Partial Fulfilment of the Requirement for the Subject.

Sumsion, R. M., June, H. M. and Cope, M. R. (2023). Measuring Food Insecurity: The Problem with Semantics. *Foods*, 12(9): 1816.

Thokchom, B., Bulgarelli, D., Schlaeppi, K. and Spaepen, S. 2021. Water Conservation in the Era of Global Climate Change, Elsevier.

Effects of varied rates of Nitrogen and Potassium Fertilizer on Oil Palm Yield on Marginal Soils

[1]Imogie, A. E.*, [2]Oviasogie, P. O., [3]Inieko, S., [4]Udughale, C. and [5]Obi, E. A.

[1] Plantations Department, [2] Oil Palm Research for Developmental Department, [3] Agronomy Division, [4] Extension Division, [5] Plant Breeding Division, Nigerian Institute for Oil Palm Research

ABSTRACT

The study investigated the effect of varied rates of nitrogen (N) and Potassium (K2O) fertilizer on oil palm yields at NIFOR Oil Palm Experimental Station, Acharu, Kogi State from 2007 to 2023. Nitrogen was evaluated at three rates 0, 0.5, and 1.0 Kg / palm / year, while Potassium was evaluated at 0, 0.5, 1.0, and 1.5 kg / palm / year respectively. All treatment plots received basal application of Phosphorous and Magnesium at the rate of 0.5 kg and 0.2 kg except the control plots respectively. The trial was a factorial experiment fitted into a Randomized Complete Block Design (RCBD) in four replicates. Data were collected on oil palm yields components (bunch number, bunch weight and fresh fruit bunches). Data collected were subjected to analysis of variance (ANOVA) and their means were compared using New Duncan's Multiple Range Test (DMRT) at 5% level of probability. Applied N and K greatly improved the nutrients status of soils resulted in significant yields of the plots treated with fertilizers over the control plots. All yield components were significantly $P \neq 0.05\%$ higher in all the palms treated with fertilizers than the control. As rates of N and K application increases the yield components and fresh fruit bunches production also increases until what seem to be optimum rates of 1.0 Kg N and 1.5 Kg K2O / palm / year was reached beyond which there was no significant increases in yield components and fresh fruit bunches production. Highest cumulative bunch numbers / hectare / year (2528), cumulative bunch weight (24,040 kg / hectare / year) and fresh fruit bunches production (224.0 Mt. / Ha) was obtained at 1.0 N and 1.0 K2O / palm / year, while highest rates of fertilizers application was not significantly different from the palms treated with 1.0 N and 1.0 K2 0 / palm / year respectively.

Key words: Fertilizers, components, marginal soils, rates, yield

***Corresponding author** imogie@yahoo.com

INTRODUCTION

The oil palm sector constitutes a significant percent of the global agricultural economy. It is vital contributor to export earnings and oil international market is worth $45 billion and it is expected to hit $64 billion by the end of 2026 (Nation Newspaper, 2020). To meet the ever increasing industrial and domestic demands of oil products, the area under cultivation in the country is being expanded. Current estimates put the total area under oil palm cultivation in the country at about 360,000 to 400,000 hectares both estate and small holder farms across 24 States. It is an important plantation crop that produces palm oil as the main source of basic ingredients for making food oil, industrial oil and biofuel. World demand for palm oil is expected to continue to increase in line with population growth, food and chemical industries (Nation Newspaper, 2020). In the process of production and industrial processing, oil palm plantations are also able to create opportunities for employment, especially in rural communities while improving the welfare of the community Oil palm utilizes a high amount of nutrients from the soil for their optimum growth and development (Tarmizi and Tayeb, 2006).

The need for fertilizers to optimize returns from oil palm is well establish. Fertilizer has played a major role in contributing to the advancement of sustainable oil palm yields. Good yield responses to fertilizers of up to 98% had been reported (NIFOR, 2016). Large responses have been demonstrated in many fertilizers experiment carried out on poorer soil in oil palm growing regions (Goh and Hardter, 2003). Nutrient demand is highly variable, depending mainly on the potential determined by the genetic limit of the planting materials and yield limit set by climatic factors. According Manjit *et* al. (2004), fertilizer responses can be site specific. Very variable results have been obtained with large differences in responses between sites that appear superficially to have similar agro-ecological environment (Foster, 2003). Fertilizer requirement is a function of soil nutrient status, hence fertilizer recommendation must take into account environmental (soil and climate) and economic constraints into consideration.

Fertilizer inputs, therefore, constitute an important investment in oil palm plantations. To optimize returns, fertilizers must be utilized efficiency and judiciously. The mineral nutrients needed to achieve high yields are taken up differently within the palm's environment and their contents differ in the various organs of the plant. When these essential nutrients are not available in sufficient amounts, deficiencies occur. Deficiency symptoms usually occur on small groups of oil palms and their intensity varies from one palm to another. For good growth and productivity, the oil palm must thrive well under optimum soil conditions with total N, available P, and available K of 0.2%, 20 mg/kg and 100 mg/ kg respectively Goh and Chew (1997). According to Goh and Chew (1997), other soil fertility parameters must also be present in the soil within suitable ranges. For instance, oil palm thrives well under CEC of 15-18 cmol kg^1, pH of 5.0-5.5, exchangeable K of 0.25-0.30 cmol kg^1 and exchangeable Mg of 0.25-0.3 cmol kg^1.

High fertility status of the supporting soils is therefore required for high productivity of oil palm per unit land area. Fertilizer recommendation for oil palm has been made on a broad scale, the need to determine soil series specific fertilizer requirement for the crop in Nigeria has long been recognized. The fertilizer requirement of the new NIFOR Elite tenera materials for marginal area especially in the transitional zones has not been determined. These second cycle tenera materials yield higher than the first cycle tenera materials and are being established extensively in different soils of the palm belt. For maximum yield, trials are necessary to determine the right quantity and ratio of the various nutrients for a particular type of soil in various ecological zones. Thus, there is a need to determine soil series specific NPKMg and trace elements fertilizer of improved tenera planting materials, with the view of determine the fertilizer require for optimum oil palm yields in marginal areas of Nigeria.

MATERIALS AND METHODS

Methodology

The experiment was conducted at the Nigerian Institute for Oil Palm Research (NIFOR) Oil Palm Experimental Station, Acharu, Kogi State. The experiment was designed to investigate the effect of nitrogen and potassium on oil palm fresh fruit bunches production with the view to establish the optimum N and K requirement by new NIFOR second cycle EWS tenera in marginal soil. The trial commenced in year 2007 when the field was established, however, treatment application commenced in 2011. The treatments were nitrogen at three levels (0, 0.5 and 1.0 kg / palm) and potassium at four levels (0, 0.5, 1.0 & 1.5 kg / palm / year) respectively. It was a 3 x 4 factorial experiment arrangement fitted into Randomized Complete Block Design (RCB), replicated 3 times. Each plot consists of 8 palms with guard row palms separating the plots and blocks. The total numbers of treatment plots were 36 that is 12 treatment plots per block. The treatments were three levels of nitrogen (N) at 0.0 kg / palm / year, 0.5 kg / palm / year and 1.0 kg / palm / year while potassium (K) at four levels 0.0, 0.5., 1.0 and 1.5 kg / palm / year with basal application of 0.5 and 0.2 kg / palm / year of Single Super Phosphorus and Kieserite to all treatments palm except the control plots. Soil and leaf tissues samples were collected before treatments application and also three months after treatment application. The soil samples were collected at two depths 0 -15 and 15 – 30 cm respectively while for plant tissues analysis leaf 17 was sampled. The collected soils samples were analysis for soil physical and chemical properties using standard laboratory procedures while the plant tissues samples were also subjected to standard laboratory analysis to determine the plant nutrient element. Data were collected on fresh fruit bunches (ffb) components (bunch number / palm, single bunch weight/ bunch, fresh fruit bunch per ton / Ha) at every fourteen days interval. The harvested bunches were weighed using a standard gauge weighing scale of 100 kg. Data collected were collated and were analyses using Analysis of Variance (ANOVA), using Genstat 2008 model and their mean separated or tested using Tukey's Honest Significant Difference at ($p \leq 0.5$) level of probability. Economics analysis of the model will be compute using principal component analysis.

RESULTS AND DISCUSSION

Yield results in the year 2012 to 2014 were presented in the 2016 NIFOR In – House Research Review held in June 2016. Statistical analysis of yield components data in year 2017 and 2019 are presented in Tables 1, 2, 3 respectively. Yield data for year 2020 are not available because harvesting was done in bulk through contract harvesting by the Officer in-Charge of the station. Results shown that treatments applications had significant effects on fresh fruit bunches (ffb) production when compared with the plots where fertilizers were not applied. Result of this study showed that yield of oil palm in marginal area can be influenced by the application of N and K fertilizers. N and K fertilizers applied significantly had remarkable influenced on oil palm yield components especially on bunch number and bunch weight. Oil palm placed high demand on soil nutrient especially nitrogen (N) which is needed for growth and development.

According to Omoti (1989) oil palm requires high amount of potassium for optimum production. As the rates of N and K increased, the yield components also increased until the optimum rates 1.0 kg N and 1.0 kg K_2O / palm / year was reached beyond which there was no significant increase in cumulative bunch number and bunch weight when N and K were applied at 1.0 Kg N and 1.5 Kg K_2O / palm / year respectively. Imogie., *et al* obtained similar results in their study of impact of N and K fertilizer on palm sap production of *Raphia hookeri*. The better yield performance of all palms treated with N and K over the palms that received no fertilizers is attributed to the applied N and K fertilizer. The palm needs N and K for growth, development and yield, while lack of N and K will affect the palm performance. Isenmila and Babalola (1989) reported significant effects of applied N and K fertilizer on oil palm growth and development.

Table 1: Influence of N and K fertilizer on cumulative bunch number per hectare year 2022

N(Urea)Kg/palm/year	K(Mop)Kg/palm/year				Total	Mean
	0	0.5	1	1.5		
0	1196	1302	1523	1545	5566	1391.5
0.5	1345	1524	1665	1670	6204	1551
1	1656	2088	2528	2518	8790	2197.5
Total	4197	4914	5716	5733		
Mean	1339	1638	1905.3	1911		

SEM ± N = 119.4; K = 217.6 N x K = 89.4

Table 2: Influence of N and K fertilizer on cumulative bunch weight kg/hectare year 2022

N (Urea) Kg/palm/year	K(Mop)Kg/palm/year				Total	Mean
	0	0.5	1.0	1.5		
0	12,744	14,955	17,514	17,868	63,081	15,770
0.5	14,694	18,926	20,978	20,675	75,273	18,818
1.0	18,557	22,350	24,040	24,028	8,975	22,243.8
Total	45,995	56,231	62,532	62,571		
Mean	15,331	18,743.6	20,844	20,857		

SEM ± N = 3026.4; K = 1056.4; N x K = 378.4

Application of N and K improved the soil nutrient thus increase palm response to applied nutrients which the plants utilized for growth, development and yield. Highest palm cumulative bunch number and bunch weight per hectare per year was obtained when N and K were applied at the rates 1.0 Kg N and 1.0 Kg K / palm / year Tables 1, 2 and 3 respectively. Nitrogen and potassium exhibited synergistic effects on fresh fruit bunches production. Single application of N or K did not perform better than when N and K was combined, thus combined application of N and K influence N and K uptake resulting in higher development and yield. In series of trials conducted in Malaysia in the early seventies Tarmizi and Tayeb (2006) reported that N and K treated oil palm had significantly taller palm, bigger stem when compared to when N and K fertilizer was applied singly.

CONCLUSION

The result obtained from this study showed that Oil palm requires macro nutrient in the order of N > K > P > Mg for optimum growth, development and yield.

Table 3: Fresh fruit bunches production (FFB Tonnes/Ha) as affected by applied N and K fertilizers in year 2022

N (kg /palm /year)		FFB (Ton / Ha)
0	0	12.7d
0	0.5	14.9d
0	1.0	17.5cd
0	1.5	17.8cd
Total		62.9
Mean		15.73
0.5	0	14.6d
0.5	0.5	18.9c
0.5	1.0	20.9b
0.5	1.5	20.6b
Total		75
Mean		18.75
1.0	0	18.6c
1.0	0.5	22.4b
1.0	1.0	24.0a
1.0	1.5	24.0a
Total		89
Mean		22.3

Mean with the same alphabet are not significantly different from one another when compared with the New Duncan Multiple Range Test (DMRT) at $p \leq 0.05\%$ Key: N: Nitrogen, K: Potassium, MNB: Mean bunch number, MSBW: Mean single bunch weight, FFB: Fresh fruit bunches

N and K exhibited synergetic effects on oil palm yield components, because single application of N or K did not perform better than when N and K were combined. High nitrogen and potassium significantly increase the fresh fruit bunch production and produce consistently heavier average bunch weight. For optimum FFB production N and K should be applied at the rates of 1.0 kg / palm / year with basal application of 0.5 and 0.2 Kg / palm / year of phosphorous and magnesium respectively.

REFERENCES

Foster, H. 2003. Assessment of Oil palm fertilizer requirements. In: T.H. Fairhurst and R. Hardter. Oil palm Management for Large and Sustainable Yields. Potash and Phosphate Institute of Canada (PPIC) and international Potash Institute, pp 231 –257.

Genstart (2008). Genstat for Windows, 7th Edition. www.vsni.co.uk/geneststt

Goh, K. and R. Hardter 2003. General oil palm nutrition. In: Thomas FairHurst and Rolf Hardter (Eds) Oil palm management for large and Sustainable Yields, pp 191 – 228.

Goh, K. J. and Chew, P. S. 1997. Interpretations of analytical data from soil survey reports for manuring recommendations. Some pointers. Annual Journal/Report 1997, Royal Johore. *Planters Association:* 25-30.

Isenmila, A. E. and Babalola, O. 1989. Effect of fertilizer application and Irrigation application on growth, root development and leaf water potential of oil palm in an ultisol. Book of Proceeding, NIFOR International Conference on Palms and Palm Produce 1: 303 – 307.

Manjit S.., Sinuroya, Z. and Hasyim, A. 2004. Yield responses of young mature oil palms to NPK fertilizer application on loamy sand in Riau Province, Indonesia. *The Planter, Kuala Lumpur* 80 (944): 689 – 708.

Nation Newspaper 2020. Charting way forward for oil palm production. The Nation Newspaper March 27th 2020 Pp 32.

NIFOR 2016. Nigerian Institute for Oil Palm Research 2016 In House Review Pp 13

Omoti, U. 1989. Fertilizer use economy in the oil palm in Nigeria through nutrient recycling. In proceeding of NIFOR International Conference on Palms and Palm Products 16: 218 – 231.

Tarmizi, A. M. and Tayeb, D. M. 2006. Nutrient demands of tenera oil palm planted on inland soils of Malaysia. *Journal of oil palm Research* 18: 204 – 209.

Response of Twenty-nine Fonio (*Digitaria* species) accessions to Leaf Spot Disease in Abeokuta, Ogun State, Nigeria

[1]Yekini, B. A.*, [1]Adigbo, S. O., [2]Enikuomehin, O. A., [2]Ishola, R. O., [2]Abayomi, G. O and [2]Olatunde, A. O.

[1] Crop Research Programme, Institute for Food Security, Environmental Resources and Agricultural Research (IFSERAR), Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.
[2] Department of Crop Protection, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.

ABSTRACT

Fungal diseases have been identified as a key challenge to achieving good yields in cereal crops worldwide. Thus, the purpose of this study was to determine the incidence and severity of leaf spot of fonio on the twenty-nine fonio accessions. The experiment was conducted during the 2024 early cropping season at the Teaching Research Farm, Federal University of Agriculture Abeokuta, Ogun State, Nigeria. The trial comprised of twenty-nine fonio accessions spread out in a Randomised Complete Block Design (RCBD) that was replicated three times. Data collected were subjected to Analysis of Variance (ANOVA) using Minitab software version 17 and the mean was separated using Tukey test at $p \leq 0.05$. The result for the percentage disease incidence and resistant level of twenty-nine accessions screened for fonio leaf spot disease under natural infection showed a significant difference among the fonio tested. The results showed that Nyamat (45.00 %) had the highest leaf spot disease, followed by Mawoi (40.00 %) while Chen which is *D. exilis* and the entire *D. iburua* did not show any leaf spot disease. The disease severity values ranged from 0.00 – 3.50 in Chen which is *D. exilis* and the entire *D. iburua* to Nyamat respectively. The resistant level showed that eighteen accessions were highly resistant, one was resistant, four were moderately resistant, five were moderately susceptible and one accession was susceptible leaf spot disease during the trial. The study recommended that the resistant accessions could be further planted in other agro ecological zone to determine resistant accessions against leaf spot disease in fonio.

Key words: disease, Fonio, fungi, leaf spot

***Corresponding Author**: yekiniba@funaab.edu.ng

INTRODUCTION

Fonio (*Digitaria* species) belongs to the family Poaceae, subfamily Panicodeae, tribe Paniceae and genus *Digitaria* (Enyiukwu and Bassey, 2020). The term fonio encompasses two species (*Digitaria exilis* Stapf-white fonio and *Digitaria iburua* Stapf-black fonio) that are genetically differentiated (CILSS, 2016). These cereals are indigenous staple crops from Western Africa particularly northern part of Nigeria, Benin, Togo, and parts of Ghana with great potential for agriculture in marginal environments (Adoukonou-Sagbadja *et al.,* 2007). FAO, TIFAD, UNICEF, WFP and WHO (2019) reported that the two main producers are Guinea with 530,000 tons, 76% of the overall production and Nigeria with 83,000 tons, 12% making a significant comeback in several producing countries. Fonio is considered as the most nutritious cereals in Africa and a good source of cysteine and high levels of sulfur amino methionine, which are important to health of humans which are often deficient in major cereals like wheat, maize and rice (Kuta *et al.,* 2003; Jideani and Jideani, 2011). It is also richer in minerals (calcium and iron) than wheat and sorghum. It was found to have high malting and brewing possibilities (Kuta *et al.,* 2003; 2005).

Fonio is a very nutritious crop but is considered to be an underutilized and under research crop. Besides, the cultivation is restricted to dry savannah zones of Nigeria. Given the resilience and short growth cycle of fonio in the face of climate change and the need for crop diversification, there is the need to evaluate its performance in the derived savannah zone. Fungi pathogen is one of the major threats to fonio production in the tropics particularly in Nigeria. This pathogen has been reported to cause up to 45 % yield reduction on grown fonio (Zinsou *et al.* 2020). The use of resistant varieties is the most economical and effective way of controlling fungal diseases mainly on resource constrained farmers' fields. However, with this small millet, a holistic approach is needed to address challenges related to diseases. Consequently, there is limited scientific data on its disease incidence and severity, disease resistance, insect pests, diseases and insect pest management, genetic diversity and optimal agronomic practices. This knowledge gap hinders efforts to improve yields and promote fonio as a sustainable crop in the face of climate change and population growth (Padulosi *et al.*, 2014). To achieve this goal, a good management strategy of the fungal pathogen requires selection of productive and resistant fonio accessions. Therefore, the studies aim to determine the incidence and severity of leaf spot of fonio on the accessions.

MATERIALS AND METHODS

Location

The experiments were conducted at the dry upper valley of FADAMA and the Crop Protection Laboratory, College of Plant Science and Crop Production, Federal University of Agriculture Abeokuta, (FUNAAB). The farm is located within latitude 7°20 N and longitude 3°23 E with an altitude of 76 m above sea level. The study area is located in the forest-savanna transition zone.

Source of thirty fonio seeds

The thirty fonio accessions were sourced from National Cereal Research Institute (NCRI), Acha House Station, Jos Plateau State, Nigeria (Table 1).

Table 1: List of thirty fonio accessions

S/No.	Accessions	S/No.	Accessions
1	Guzuk 2	16	Nebang
2	Achimawai	17	Jakalak
3	Mboseke	18	Amundel
4	Mawoi	19	Nasheleng
5	Nyamat	20	Ganawuri
6	Badama	21	Nanagai
7	Dipya	22	Dinat
8	Siken	23	Zor
9	Loma	24	Pelking
10	Chen	25	Machach
11	Gong-arandong	26	Jarab
12	Dicksun	27	Dampep
13	Gotip	28	Sunpiya
14	Chu	29	Danto
15	Fang-roi	30	Ebuth

Experimental design and treatments

The experiment was laid out in Randomized Complete Block Design (RCBD) and replicated three times. The total experimental plots area (73 m x 8 m) and plot size 2 m x 2 m. Two species of the fonio used were *Digitaria exilis* Stapf-white fonio and *Digitaria iburua* Stapf-black fonio. Each of the species was dibbled at the spacing of 50 cm in row sowing.

Disease assessment

At the first appearance of the disease, data were collected on disease symptoms. Leaf spot incidence and severity were taken at about 15 cm foot size in the central row, and calculated using the formulae below:

$$\text{DI (\%)} = \frac{Number\ of\ diseased\ plant}{Total\ number\ of\ plants\ per\ plot}\ x\ 100$$

Disease Severity (DS) is calculated using the formulae.

$$\text{Disease severity (DS)} = \frac{\sum n}{N \times S} \times 100$$

where, Σ = Summation, n = number of infected leaves, N = number of leaves assessed, S = maximum numerical grade.

Disease severity scale is presented in Table 2.

Statistical analysis

Data collected were subjected to Analysis of Variance (ANOVA) using Minitab software version 17 and the mean was separated using Tukey test at $p \leq 0.05$.

RESULTS AND DISCUSSION

Fonio foliar diseases observed on the field

The results revealed the occurrence of leaf spot on fonio (Figure 1). The symptom of leaf spot was characterised with a pin-point head, which may be singly, chain or clustered with dark brown discolouration on the leaves.

Table 2: Disease Severity rating scale for leaf spot of fonio

Grade	Reaction	Kiran-Babu *et al.,* 2013 Scale Equivalent	Host Response
0	No symptoms	No symptoms	Highly Resistant
1	1 – 5% leaf area covered by brown leaf spot	1-5 % leaf area covered by brown leaf spot	Resistant
2	6 – 15% leaf area covered by brown leaf spot	6-20 % leaf area covered by brown leaf spot	Moderately Resistant
3	16 – 25% leaf area covered by brown leaf spot	21-40 % leaf area covered by brown leaf spot	Moderately Susceptible
4	26-50 leaf area covered by brown leaf spot	41-50 % leaf area covered by brown leaf spot	Susceptible
5	>51% leaf area or all the leaves dead	51-100 % leaf area or all the leaves dead	Highly Susceptible

The accessions *D. exilis* are susceptible while *D. iburua* were totally immune or not showing the symptom of the leaf spot during the growing season. The disease incidence and severity differed across the twenty-nine fonio accessions. The highest incidence and severity values were found in *D. exilis* which showed that this species is more vulnerable to fonio leaf spot. Manza *et al.* (2013) reported highest disease incidence and severity of Curvularia leaf spot occurrence in Riyom, Plateau State of Nigeria. In addition, accessions *D. iburua* in Nigeria. The disease severity values ranged from 0.00 – 3.50. The resistant level showed that nineteen accessions were highly resistant, one was resistant, four were moderately resistant, five were moderately susceptible and one accession was susceptible leaf spot disease during the trial (Table 3). Similarly, Valerien *et al.* (2020) reported that three accessions were resistant, 6 were moderately resistant, 6 were moderately susceptible and 8 were susceptible.

Percentage disease incidence and resistant level of twenty-nine accessions screen for fonio leaf spot disease under natural infection

The result for the percentage disease incidence and resistant level of twenty-nine accessions screened for fonio leaf spot disease under natural infection showed a significant difference among the fonio tested. Percentage disease incidence showed that Nyamat (45.00 %) had the highest leaf spot disease, followed by Mawoi (40.00 %) while *D. iburua* did not showed any leaf spot disease. The result is similar to the findings of Manza *et al.* (2013) who observed diversity in disease reactions of sixteen fonio.

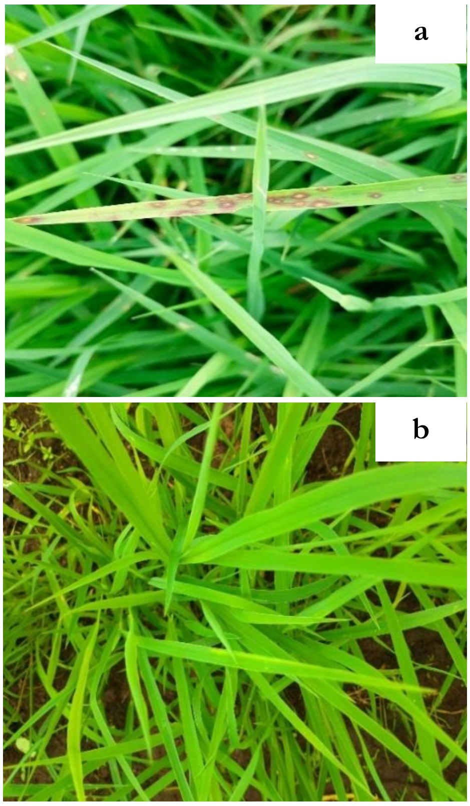


Figure 1: Brown leaf spot (a) and healthy plant (b) of fonio

CONCLUSION

The study revealed the occurrence of leaf spot on fonio plant at various stages. The study also revealed that *D. ibruua* (black fonio) accessions are more susceptible to fungal infection than *D. exilis* (white fonio). The resistant levels for leaf spot disease showed that sixteen accessions were highly resistant, one was moderately resistant, six were moderately susceptible while six were also susceptible.

REFERENCES

Adoukonou-Sagbadja, H, Dansi, A, Vodouhe, R. and Akpagana, K. 2006. Indigenous knowledge and traditional conservation of Fonio millet (*Digitaria exilis* Stapf, *Digitaria iburua* Stapf) in Togo. *Biodiversity and Conservation* 15: 2379–2395. doi:10.1007/s10531-004-2938-3

Enyiukwu, D. N. and Bassey, I. N. 2020. Fonio (*Digitaria spp.*): The Good Tasting, Potential Food Security Cereal for Africa begs for Research Attention. *Direct Res. J. Agric. Food Sci.* 8(7): 231-238.

FAO, IFAD, UNICEF, WFP and WHO. (2019). *The State of Food Security and Nutrition in the World 2019. Safeguarding against economic slowdowns and downturns.* FAO.

Jideani, I. A. and Jideani, V. A. 2011. Developments on the cereal grains *Digitaria exilis* (acha) and *Digitaria iburua* (iburu). *Journal of Food Science and Technology,* 48(3): 251–259.

Kuta, D. D., Kwon-Ndung, E., Dachi, S., Ukwungwu, M. and Imolehin, E. D. 2003. Potential role of biotechnology tools for genetic improvement of lost crops of Africa: The case of Fonio (*Digitaria exilis and Digitaria iburua*), Mini review, *Afr J Biotechnol.*, 2: 580-585.

Kuta, D. D., Kwon-Ndung, E., Dachi, S., Bakare, O. and Ogunkanmi, L. A. 2005. Optimization of protocols for DNA extraction and RAPD analysis in West African Fonio (*Digitaria exilis* and *Digitaria iburua*) germplasm characterization, *Afr. J. Biotechnol.,* 4: 1368-1371.

Mamza, W. S., Zarafi, A. B., Dachi, S. N., Bright, E. O. and Ukuwngwu, M. N. 2013. Incidence and severity of Curvularia leaf spot on *Digitaria iburua* (fonio) in Riyom, Plateau State, Nigeria. P 88. In: Hall, R.A., P. Rudebjer, S. Padulosi. (eds.) 2013. 3rd International Conference on: Neglected and Underutilized Specie. (NUS): for a Food-Secure Africa. Accra, Ghana, 25-27 September 2013. Book of Abstracts. Bioversity International, Rome, Italy.

Padulosi, S., Amaya, K., Jäger, M., Gotor, E., Rojas, W. and Valdivia, R. 2014. A holistic approach to enhance the use of neglected and underutilized species:

The case of Andean grains in *Bolivia and Peru. Sustainability*, 6(3): 1283–1312.

Valérien, Z. A., Emmanuel, S., Mahfouz, D., Gildas, T., Ayouba, K. T., Néhal, D. M. and Cyrille, K. 2020. Curvularia leaf spot on white fonio accessions in the commune of Boukoumbe in north Benin. *Journal of Animal and Plant Sciences*, 44(3): 266-272.

Zinsou, A. V., Sekloka E, Dramane M., Tchemadon G., Kora T. A., Djaouga M. N. and Kanlindogbe C. 2020. Curvularia leaf spot on white fonio accessions in the commune of Boukoumbe in north Benin. *Journal of Animal and Plant Sciences*, 44(3): 7695-7706

Table 3: Percentage disease incidence and resistant level of twenty-nine fonio accessions screened for leaf spot disease under natural infection

Treatments	Disease incidence (%)	Disease severity	Status
Guzuk 2	20.00cd	2.00cde	MR
Achimawai	30.00abc	3.00ab	MS
Mboseke	23.33bcd	3.00ab	MS
Mawoi	40.00a	3.00ab	MS
Nyamat	45.00a	3.50a	S
Badama	23.33bcd	1.83de	MR
Dipya	30.00abc	2.33bcd	MR
Siken	18.33cd	1.33e	R
Loma	13.33de	1.83de	MR
Chen	0.000e	0.00f	HR
Gong-arandong	18.33cd	2.50bcd	MS
Dicksun	36.67ab	2.83abc	MS
Gotip	0.00e	0.00f	HR
Chu	0.00e	0.00f	HR
Fang-roi	0.00e	0.00f	HR
Nebang	0.00e	0.00f	HR
Jakalak	0.00e	0.00f	HR
Amundel	0.00e	0.00f	HR
Nasheleng	0.00e	0.00f	HR
Ganawuri	0.00e	0.00f	HR
Nanagai	0.00e	0.00f	HR
Dinat	0.00e	0.00f	HR
Zor	0.00e	0.00f	HR
Pelking	0.00e	0.00f	HR
Machach	0.00e	0.00f	HR
Jarab	0.00e	0.00f	HR
Dampep	0.00e	0.00f	HR
Sunpiya	0.00e	0.00f	HR
Danto	0.00e	0.00f	HR
Means	10.29	0.937	
SE	1.62	0.138	
CV (%)	146.82	137.84	

Means in the same column followed by different alphabets are significantly different ($p \leq 0.05$) using Tukey. SE means Standard Error while CV means Coefficient of Variation. HR=Highly Resistant, R=Resistant, MR=Moderately Resistant, MS=Moderately Susceptible and S=Susceptible

Agronomic performance of sorghum varieties intercropped with cassava as a climate - smart agriculture strategy in the forest-savannah transition agro-ecology

[1]Fadeyi, O. J.*, [2]Fabunmi, T. O., [1]Olowe, V. I. O. and [3]Adejuyigbe, C. O.

[1] Institute of Food Security, Environmental Resources and Agricultural Research (IFSERAR), [2] Department of Plant Physiology and Crop Production, [3] Department of Soil Science and Land Management, Federal University of Agriculture, Abeokuta, Ogun State

ABSTRACT
In response to the urge from the 13th sustainable development goal (SDG), climate - smart agriculture becomes imperative to ensure sustainable crop production. This study examined the agronomic performance of three improved sorghum varieties intercropped with cassava in response to poultry manure application at the Institute of Food Security, Environmental Resources and Agricultural Research, FUNAAB (June – December, 2023) and the Organic Agriculture Professionals in Tertiary Institutions in Nigeria, FUNAAB (September – November, 2024). The experiment was a 3 × 6 factorial fitted into a randomized complete block design with three replications. Treatments consisted of poultry manure rates (0, 2.5, and 5.0 t ha^{-1}) and the cropping systems (SAMSORG 44/TME 419; SAMSORG-47/TME 419; SAMSORG-48/TME 419; SAMSORG 44 Sole; SAMSORG-47 Sole and SAMSORG-48 Sole). Results revealed that plant height, dry matter accumulation, panicle weight and seed yield significantly ($p < 0.05$) increased with increase in manure application but were not significantly ($p \leq 0.05$) affected by intercropping. Significant ($p \leq 0.05$) interaction between manure and cropping systems indicated highest seed yield of 2748.4 at 5.0 t ha^{-1} manure application particularly for SAMSORG 44 which was comparable ($p \leq 0.05$) to the intercrop counterpart and significantly higher than the average yield values in Africa (924.8 kg/ha) and the world (2534.2 kg/ha). Consequently, the study confirms the compatibility of sorghum and cassava (TME 419) in intercropping systems and recommends their integration as a viable climate-smart strategy for sustainable agriculture in the forest-savannah transition agro-ecological zone.

Key words: Climate-smart agriculture, intercropping, *Sorghum bicolor*, sorghum varieties, sustainable agriculture,

***Correspondence author**: fadeyioj@funaab.edu.ng

INTRODUCTION
The 13th sustainable development goal (SDG) urges to take urgent action to combat climate change and its impacts, in this vein, climate - smart agriculture (CSA) is imperative to ensure sustainable crop production. Climate change impacts include increased desertification, prolonged dry season shift in the rainfall season, later onset of rainfall, early cessation of rainfall, reductions in the length of the growing season, floods, storms, late setting of steady rainfall, sudden drought experience, reduced production (Onuk *et al.*, 2019). The role of sorghum in CSA is therefore essential since the crop is known to be drought tolerant, resistant to pest and diseases and adaptive to harsh arid and semi-arid environment, characterized by an extensive root system, waxy bloom on leaves that reduces water loss, ability to stop growth in periods of drought and resume it when the stress is relieved, require relatively less water, has high varieties of germplasm, has higher nutritional value (Chibarabada *et al.*, 2017; Hadebe *et al.*, 2017). Consequently, the objective of this study is to evaluate the agronomic performance of some sorghum varieties in a cassava based intercropping system to ensuring sustainable production in the Forest – Savannah Transition Agro-ecology in the face of the prevailing shifts in climatic conditions.

MATERIALS AND METHODS

This trial was carried out at the certified organic farm of the Organic Agriculture Professionals in Tertiary Institutions in Nigeria (OAPTIN), FUNAAB (September – November, 2024). Composite soil samples were collected with the aid of an auger before planting to evaluate the physico-chemical properties of the experimental site (Table 1). Monthly rainfall distribution and mean temperature during the period of the study was taken (Table 2). Three poultry manure treatments (0, 2.5, 5.0, t. ha^{-1}) were tested on three sorghum varieties (SAMSORG-44, SAMSORG-47 and SAMSORG-48) intercropped with the cassava variety, TME 419. The experiment was a 3 × 6 factorial. Factor 1 - The poultry manure rates (3): 0, 2.5, and 5.0 t ha^{-1}. Factor 2 - the cropping systems (6): SAMSORG 44/TME 419 Intercrop; SAMSORG-47/TME 419 Intercrop; SAMSORG-48/TME 419 Intercrop; SAMSORG 44 Sole; SAMSORG-47 Sole and SAMSORG-48 Sole. Tillage operation was carried out, which include ploughing (twice at two weeks interval) and harrowing with the field divided into different experimental units. Poultry manure was incorporated according to the experimental design and treatment after land preparation. Planting was done on August 6th 2024 at a spacing of 75 × 25 cm. Manual weeding was carried out at 3, 6, 9 and 12 weeks after sowing (WAS) to disallow effects of weeds on the cultivated crop. Data Collected include dry matter accumulation, plant height, stem girth, number of leaves, panicle length, panicle diameter, panicle weight, seed weight/plot, threshing percentage and seed yield. The data collected were subjected to analysis of variance (ANOVA) and significant ($p \leq 0.05$, F-test) treatment means of main effects and interactions were separated using Duncan's Multiple Range Test (DMRT).

Table 1: Poultry manure and pre-treatment physico-chemical properties of the soil of the experimental site

Parameters	Poultry manure	Soil
Physical properties		
Sand (%)		68.7
Silt (%)		14.6
Clay (%)		16.7
Textural class		Sandy-loam
Chemical properties		
pH		6.92
Organic carbon (%)	10.8	1.96
Organic matter (%)		3.37
N (%)	4.10	0.20
Available P (mg/kg)	0.083	7.77
Ca (cmol/kg)	12.77	4.63
Mg (cmol/kg)	1.9	2.96
Na (cmol/kg)	2.4	0.22
K (cmol/kg)	0.48	0.46

Table 2: Meteorological data during the experiment in 2023

Month	Total rainfall (mm)	Relative Humidity (%)	Temp (°C)		Sunshine (Hrs)
			Max	Min	
June	217.3	85.9	21.9	31.8	3.5
July	148.9	81.9	21.1	27.5	3.1
Aug	56.4	81.8	20.8	30.3	2.4
Sept	131.2	81.0	20.9	31.4	3.0
Oct	236.2	80.8	21.4	32.7	5.4
Nov	238.4	79.3	21.9	32.3	4.9

Source: Department of Agro Meteorology and Water Resources Management, Federal University of Agriculture, Abeokuta

RESULTS AND DISCUSSION

Effects of poultry manure on and cropping system on growth, yield and yield components of sorghum varieties in 2024

The application of poultry manure had a significant ($p \leq 0.05$) impact on dry matter accumulation, plant height, and number of leaves in both years (Table 3). This increase was dose-dependent, indicating that higher quantities of applied manure resulted in greater dry matter accumulation. Apparently, plots receiving 5 t. ha^{-1} poultry manure exhibited the highest measurements, signifying the positive influence of poultry manure on sorghum growth. This aligns with the notion that poultry manure serves as a valuable organic nutrient source, promoting plant growth and development (Gupta *et al*., 2020). However, cropping system did not show a significant ($p \leq 0.05$) effect on all growth parameters of the sorghum varieties. This result obtained, exemplifies the compatibility of these two test crops as complementary intercrop species. This finding aligns with an earlier study of Ibrahim *et al.* (2023), who reported non-significant ($p \leq 0.05$) reductions in sorghum growth parameters under cassava intercropping, attributing this to complementary resource use.

Application of poultry manure significantly ($p \leq 0.05$) enhanced panicle weight, seed weight/plot, threshing percentage and seed yield (Table 4). These effects were dose-dependent, with higher manure rates resulting in improved sorghum yield. The highest values were observed at 5.0 t ha^{-1}, highlighting the effectiveness of poultry manure in enhancing sorghum yield. This finding agrees with previous studies emphasizing the benefits of poultry manure as a rich organic nutrient source that enhances crop yield (Gupta *et al.,* 2020). Conversely, cropping system did not exert a significant ($p \leq 0.05$) influence on all measured yield and yield traits (Table 4). This suggests a level of biological compatibility between sorghum and cassava, supporting the feasibility of their intercropping in CSA systems. Significant ($p \leq 0.05$) interaction between manure and cropping system on seed yield production indicated the highest seed yield of 2748.4 kg/ha at 5.0 t ha^{-1} manure application particularly for SAMSORG 44 which is significantly higher than the average yield values of 924.8 kg/ha in Africa and 2534.2 kg/ha in the world (Khalifa and Eltahir, 2023) (Figure 1). This strong variety × environment interaction highlights the importance of selecting varieties best suited for input management, as indicated by Tariq *et al*., (2022). It also reinforces the need for breeding programs to consider nutrient responsiveness as a trait of interest in variety development aimed at sustainable farming systems.

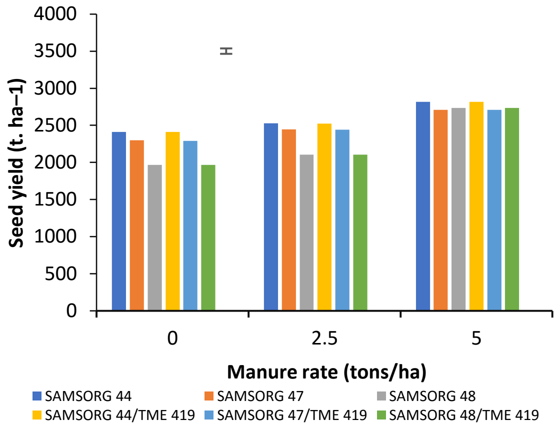


Figure 1: Interaction of Manure rate and cropping system on seed yield of Sorghum in 2024

CONCLUSION

This study concludes that poultry manure significantly enhances sorghum yield and yield components, particularly at the highest rate of 5.0 t ha^{-1}. The results indicate that sorghum and cassava are potentially compatible arable species for complementary intercrop cropping system. Moreover, the compatibility of sorghum and cassava in intercropping systems supports their integration as a viable climate-smart strategy for sustainable agriculture in the forest-savannah transition agro-ecological zone.

REFERENCES

Chibarabada, T. P., Modi, A.T. and Mabhaudhi, T. 2017. Expounding the value of grain legumes in the semi- and arid tropics. *Sustainability* 9(1): 60.

Gupta, N. R., Maziya-Dixon, B. and Gichuki, S. 2020. Sustainable Use of Poultry Manure for Crop Production and Environmental Management: A Review. *Journal of Soil Science and Plant Nutrition,* 20(3): 1098-1111.

Hadebe, S. T., Modi, A. T. and Mabhaudhi, T. 2017. Drought Tolerance and Water Use of Cereal Crops: A Focus on Sorghum as a Food Security Crop in Sub-Saharan Africa. *Journal of Agro Crop Science* 203:177-191.

Table 3: Growth of three sorghum varieties (SAMSORG 44, SAMSORG 47, and SAMSORG 48) as influenced by organic soil amendment with poultry manure in 2024

Treatments	Plant height (cm)			Number of leaves			Stem girth (cm)			Dry matter accumulation (g)		
	4 WAS	6 WAS	8 WAS	4 WAS	6 WAS	8 WAS	4 WAS	6 WAS	8 WAS	4 WAS	6 WAS	8 WAS
Manure rate (t. ha^{-1}) (M)												
0	55.9	63.4 b	114.8 b	5.3	9.3	11.7 b	9.9	13.0 c	21.1 c	46.9	46.7 a	50.4 c
2.5	52.0	95.0 a	170.4 a	5.3	8.7	11.0 b	9.8	15.4 b	25.8 b	47.6	49.5 ab	55.1 b
5	57.5	97.1 a	179.3 a	5	9.1	13.9 a	11.4	19.1 a	29.4 a	47.8	52.2 a	60.2 a
SED± df (2)	1.1	3.8	5.7	0.1	0.2	0.3	0.4	0.5	0.8	0.4	0.9	0.9
F test	ns	**	**	ns	ns	**	ns	**	**	ns	*	**
Cropping System (C)												
Sole SAMSORG 44	49.7 b	98.9 a	156.9 a	5.0	8.4	12.6	8.8	17.1	27.7	49.0 a	54.7 a	57.8
Sole SAMSORG 47	56.6 a	77.1 b	123.1 b	5.0	7.9	10.9	8.9	15.3	24.4	47.2 b	48.3 b	53.8
Sole SAMSORG 48	59.1 a	79.6 b	154.6 a	5.7	7.8	12.0	9.0	15.0	24.3	45.8 b	45.4 b	54.0
SAMSORG 44/ TME 419	48.8 b	98.6 a	156.2 a	5.2	8.2	12.0	8.4	16.8	27.5	49.0 a	54.7 a	57.8
SAMSORG 47/ TME 419	55.9 a	75.9 b	122.9 b	4.8	7.4	10.8	7.9	15.5	24.6	47.2 b	48.3 b	53.8
SAMSORG 48/ TME 419	58.5 a	78.4 b	154.8 a	5.3	7.5	11.8	8.5	15.8	25.5	45.8 b	45.4 b	54.0
SED± df (5)	0.8	2.6	4	0.2	0.1	0.2		0.4	0.5	0.3	0.6	0.6
F test	*	**	*	ns	ns	ns	ns	ns	ns	**	**	ns
Interaction												
M x C	**	**	**	ns	ns	ns	ns	ns	ns	**	**	**

In a column, means followed by similar letters are not significant ($p > 0.05$) different at 5% level of probability using Duncan's Multiple Range Test (DMRT). WAS = Weeks after sowing. ns = not significant ($p > 0.05$). * = Significant ($p \leq 0.05$) at 5% level of probability. ** = Significant ($p \leq 0.01$) at 1% level of probability.

Table 4: Effects of poultry manure and cropping system on yield and yield components of sorghum varieties intercropped with cassava in 2024

Treatments	Panicle length (cm)	Panicle diameter (cm)	Panicle weight (g plant^{-1})	Seed weight/plot (g plant^{-1})	Threshing percentage (%)	Seed yield (kg. ha^{-1})
Manure rate (t. ha^{-1}) (M)						
0	32.8	6.6	47.8 b	41.8 b	87.1 b	2228.1 b
2.5	37.1	6.8	48.4 b	44.3 b	91.7 a	2368.0 b
5.0	35.0	6.2	55.8 a	51.5 a	92.7 a	2748.4 a
SED± df (2)	1.4	0.2	0.9	1.0	0.6	52.9
F test	ns	ns	**	**	**	**
Cropping System (C)						
Sole SAMSOARG 44	30.3	6.5	53.0	48.5	91.7	2498.9
Sole SAMSOARG 47	38.4	6.8	51.4	46.5	90.4	2350.1
Sole SAMSOARG 48	36.2	6.2	47.6	42.6	89.3	2112.0
SAMSORG 44/ TME 419	30.6	6.3	53.4	47.8	90.6	2488.6
SAMSORG 47/ TME 419	37.9	6.4	50.9	45.9	89.8	2347.5
SAMSORG 48/ TME 419	35.5	6.0	48.1	41.8	88.7	2121.3
SED± df (5)	1.4	0.2	0.9	1.0	0.6	51.7
F test	ns	ns	ns	ns	ns	ns
Interaction						
MXC	ns	ns	ns	ns	ns	**

In a column, means followed by similar letter are not significantly different at 5% level of probability using Duncan's. ns = not significant. ** = Significant at 1% level of probability.

Ibrahim, H., Bello, N. J. and Oyetunji, O. J. 2023. Performance of sorghum intercropped with cassava under different nitrogen levels in the Guinea savanna. *Journal of Crop Production*, 56(1): 45–53.

Khalifa, M. and Eltahir, E. A. B. 2023. Assessment of global sorghum production, tolerance, and climate risk. Front. Sustain. Food Syst. 7:1184373. doi: 10.3389/fsufs.2023.1184373.

Onuk, E. G., Ibrahim, M. and Atala, T. K. 2019. Climate change and agricultural adaptation strategies in Nigeria: A review. *Nigerian Journal of Agriculture, Food and Environment*, 15(2): 1–6.

Tariq, A., Ali, S., Abbas, F. and Nasim, W. 2022. Trait-based breeding and nutrient management for improved crop productivity. *Frontiers in Sustainable Food Systems*, 6: 852738.

Effect of land use change on soil properties at Federal University of Agriculture Abeokuta, Ogun state, Nigeria

Oyeyemi, O., Tobore A., Adebayo I., Alaofin A.
Department of Soil Science and Land Management,
Federal University of Agriculture Abeokuta, Ogun state, Nigeria.

ABSTRACT

Land use changes significantly alter soil properties, affecting soil fertility, structure, and long-term productivity. This study assessed the effects of various land use types such as vegetation, wetland, waterbody, bare land and built-up area on soil properties within the Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, Nigeria to support sustainable land management. Landsat 7 ETM + and 8 OLI of 2005, 2015, and 2025 were sourced from the United States Geological Survey (USGS) repository and analysed using the Supervised Maximum Classification Algorithm (SMCA) in ArcGIS 10.5. A total of 25 soil samples were collected (0–15 cm) across the land use types and were subjected to standard laboratory analysis. The result showed a decrease in vegetation (33.6 %), shift in wetland (16.8 %), along with transition in waterbody (2.2 %) into significant increase of built-up area (21.7 %) and bare land (25.6 %) respectively from 2005 to 2025. The outcome revealed that the land use changes significantly depleted the soil properties of the studied area. The findings underscore the critical relationship between land use change and soil properties, emphasizing the urgent need to restore soil fertility and ensure long term productivity of the studied area. Keywords: Land use change, soil properties, soil fertility, soil degradation, land cover dynamics, geospatial analysis.

Key words: ……………………

***Corresponding Author:** ……………

INTRODUCTION

Land use refers to the process by which human activities transform natural landscapes, emphasizing economic uses such as agriculture, urbanization, and industrialization. These nonlinear changes often disrupt ecosystems, stress the environment, and potentially create vulnerabilities for human populations (Deng *et al*. 2024; Nayak *et al*. 2024). As such, the assessment of both current land use trajectories and future projections under different scenarios is critical to achieving precision agriculture (Paul and Rashid, 2017). Hence, assessing land use changes is essential for managing terrestrial eco biodiversity, ensuring soil quality and promoting agricultural sustainability (Bununu *et al*., 2023).

Soil plays a vital role in global environmental change, as its formation and functioning are driven by the interacting influences of climate, topography, parent material, biotic activity, and temporal dynamics (MDPI, 2024). More importantly, soil properties e.g., soil organic carbon, available phosphorus, soil pH, total nitrogen, etc. are fundamental components for maintaining soil quality and are integral to the sustenance of essential ecosystem functions (Zhou *et al.,* 2021). However poor land management has degraded vast amounts of land, reduced the ability to produce food, and are a major threat to livelihoods especially in emerging countries (Montanarella *et al*., 2022). While land use change is a major problem that affects the physicochemical properties of soils (Bahrami *et al*., 2010; Admasu *et al*., 2014; Aredehey *et al*., 2019), many of these changes often lead to conversion of suitable agricultural lands to build up environments. Furthermore, continuous use of land for cultivation and grazing purposes always result in the loss of soil nutrients (Molla *et al.*, 2010; Gebreselassie and Ayanna, 2013). As a result, land use changes cause a decline in crop production due to depletion of essential soil nutrients (Yitbarek *et al.*, 2013; Admasu *et al.*, 2014).

Therefore, understanding these effects is essential for ensuring sustainable land management within the Federal University of Agriculture Abeokuta. Hence, this study provides an insight on how different land uses impact soil properties, aiding in the formulation of best land use acts and management practices to enhance soil sustainability (Olorunfemi *et al.*, 2018).

MATERIALS AND METHODS

Study area

The study was conducted within the Federal University of Agriculture, Abeokuta (FUNAAB), in Ogun State, southwestern Nigeria. The area lies between latitudes 7°13' N and 7°20' N and longitudes 3°20' E and 3°28' E, covering an estimated 10,000 hectares of land (Ufoegbune *et al.*, 2010), located North of Abeokuta. The study area is characterized by diverse land use comprising of experimental agricultural plots, cultivated farmland, and areas undergoing urban expansion indicating dynamic land use transitions across the University landscape (Anthony, 2023).

The terrain features a mix of undulating and flat topography, interspersed with river valleys and seasonal depressions (Gbadebo *et al.*, 2023; Ojekunle *et al.*, 2023). The region experiences a humid tropical climate with distinct wet and dry seasons, and Standardized Precipitation Index (SPI) data indicate both moderate and very wet years (Tobore *et al.*, 2021). Although originally a tropical rainforest zone, vegetation has been altered by agriculture and urban development (Oke and Adeyemi, 2019). The dominant soil types in the study area include Ferric Luvisols, Ferric Cambisols, and Ferric Lixisols (Fig.1) while lowland areas are primarily composed of Gleyic Luvisols and Lithosols. These soils exhibit varying degrees of gravel content and are prone to seasonal waterlogging in depressional zones (FAO, 2015; Soil Science Division Staff, 2017; Tobore *et al.*, 2025). The area is underlain by metamorphic rocks of the basement complex, of pre-Cambrian age. The soil in this region supports the growth of lowland rainforest vegetation (Ekanade, 2007).

Land use analysis and data sources

Landsat 7 ETM + and 8 OLI of the years 2005, 2015, and 2025 were obtained from the United States Geological Survey (USGS) repository and were analyzed using the Supervised Maximum Classification Algorithm (SMCA).

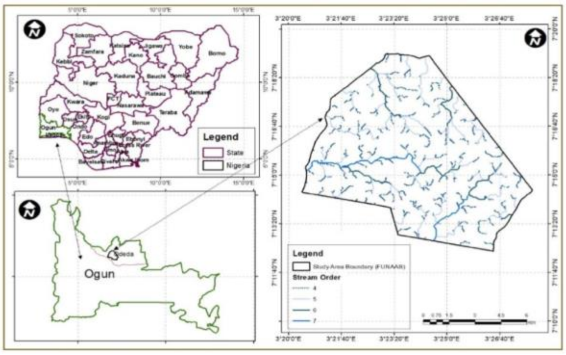


Figure 1: Location map of the studied area

The classification process was carried out using ArcGIS 10.5 software. Supervised classification, a widely recognized technique in remote sensing, involves the use of predefined training samples to categorize unknown pixels. By referencing existing land use types, the method groups image pixels into their respective categories, thereby enhancing classification accuracy. However, the reliability of this method is significantly influenced by the quality and representativeness of the selected training samples (Shen *et al.*, 2023).

To complement the image analysis, the geographical coordinates (latitude and longitude) of the field sampling points were recorded using a Global Positioning System (GPS) device. These coordinates were organized in an Excel spreadsheet alongside corresponding laboratory results to facilitate seamless data management and integration with the remote sensing outputs. The classification identified five major land use categories in the studied area namely: bare land, vegetation, wetland, waterbody, and built-up area (Anderson, 1976; Adepoju *et al.*, 2019).

Soil Sampling and Design

A total of 25 soil samples (5 Land use x 5 soil samples x 1 site were sampled through simple random soil survey technique. This method was employed to ensure unbiased selection and statistical representativeness of the studied area for assessing soil properties.

Surface soil were sampled at depth of 0-15cm along predominant land uses to capture the status of soil properties for a comprehensive understanding of soil health (Smith *et al.*, 2023). The following soil parameters were determined: soil texture, pH, organic carbon (OC), total nitrogen (TN), available phosphorus (AP), and exchangeable bases (Ca^{2+}, Mg^{2+}, K^{+}, and Na^{+}). Particle size distribution was analyzed using the hydrometer method as described by Day (1995). Soil pH was measured to evaluate the soil's acidity or alkalinity using two extractants: distilled water for active pH and potassium chloride (KCl) for potential acidity. These dual measurements provided a broader assessment of soil reaction under varying conditions, which is essential for appropriate soil management. Organic carbon (OC) was determined using the dichromate oxidation method (Walkley and Black, 1934). Total nitrogen (TN) was analyzed by micro-Kjeldahl digestion, distillation, and titration procedure (Bremner and Mulvaney, 1982). Available phosphorus (AP) was extracted using the Olsen method (Olsen *et al.*, 1954). Calcium (Ca^{2+}) and magnesium (Mg^{2+}) concentrations were determined using atomic absorption spectrophotometry, while potassium (K^{+}) and sodium (Na^{+}) were measured with a flame photometer (Thomas, 1990).

RESULTS

Distribution of land use cover classes of Funaab in 2005, 2015 and 2025

Landsat 7 ETM + and 8 OLI of the year 2005, 2015, and 2025 obtained from the United States Geological Survey (USGS) repository and analyzed using the Supervised Maximum Classification Algorithm (SMCA) revealed the distribution of land use cover classes in the studied area (Fig. 2). Over this period, vegetation cover decreased from 211.9 sqkm (48.6%) in 2005 to 169.7 sqkm (39%) in 2015 and further to 146.6 sqkm (33.6%) by 2025. A similar trend is seen in wetlands, which decreased from 185.5 sqkm (42.6%) in 2005 to 150.7 sqkm (34.6%) in 2015, and this significantly reduced to 73.2 sqkm (16.8%) by 2025. Conversely, waterbody showed a fluctuating trend. It increased slightly from 5.7 sqkm (1.3%) in 2005 to 27.2 sqkm (6.2%) in 2015, before declining to 9.7 sqkm (2.2%) by 2025. Notably, the most substantial expansions were observed in built-up areas and bare lands. Built-up land increased markedly from 14.0 sqkm (3.0%) in 2005 to 47.2 sqkm (10.8%) in 2015, and further to 94.6 sqkm (21.7%) by 2025. Similarly, bare land expanded significantly, from 18.6 sqkm (4.3%) in 2005 to 40.9 sqkm (9.4%) in 2015, and reached 111.5 sqkm (25.6%) in 2025 (Table 1).

Overall, the land use cover class reveals a significant decline in vegetation and wetlands, which could imply poor land use planning, and an increase in built-up areas and bare lands, due to urban expansion and land degradation.

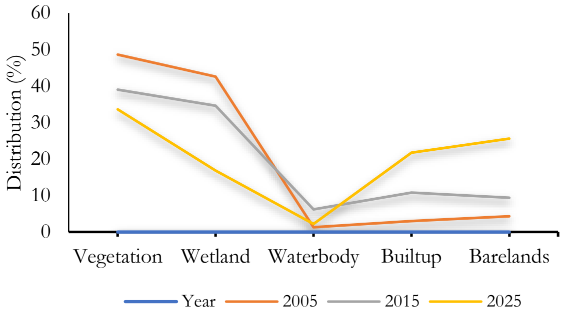


Figure 2. Distribution of land use cover classes of FUNAAB in 2005, 2015 and 2025

Spatial change detection of FUNAAB in 2005, 2015 and 2025

Land use within Federal University of Agriculture Abeokuta (FUNAAB) has changed noticeably over time, revealing patterns of development, expansion, and shifting land demands. The present study utilized the Landsat 7 ETM + and 8 OLI of the year 2005, 2015, and 2025 to assess the rate of these changes (Table 1.). From 2005 to 2015, vegetation decreased by 42.2 sqkm, and wetland declined by 34.8 sqkm. Waterbody, however, had an increase of 21.5 sqkm during this period. Built-up areas expanded significantly, increasing by 33.2 sqkm, while bare land also grew by 22.3 sqkm between 2015 and 2025, the decline in wetland became even more substantial, and with a decrease of 77.1 sqkm. Vegetation also continued to reduce, decreasing by 23.1 sqkm. Waterbody, following its previous expansion, declined by 17.5 sqkm. In contrast, built-up areas experienced a major increase of 47.4 sqkm, while bare land expanded significantly by 70.6 sqkm.

Over the 20-year period from 2005 to 2025, vegetation and wetland recorded substantial reduction of 65.3 sqkm and 111.9 sqkm, respectively. Waterbody showed a slight increase of 4 sqkm. Built-up area expanded by 80.6 sqkm, while bare land experienced the most notable growth, rising by 92.9 sqkm.

Physical and Chemical Conditions of the Studied Soil

Particle size analysis results of the studied area at depth 0-15cm

The soils within the studied area showed notable variations in the proportions of sand, silt, and clay across the different sampling points. Despite these variations, all samples were classified as sandy clay loam, indicating a dominance of sand particles alongside moderate amounts of clay and lesser quantities of silt (Table 2). The differences in particle size fractions can be attributed to the impact of land use and cover changes on soil structure. Soils under cultivation, for example, may experience aggregate breakdown and selective removal of finer particles due to tillage and erosion, while those under natural vegetation tend to maintain more stable structures (Adimassu *et al*., Tesfahunegn *et al*., 2011).These revealed that while the overall textural class remains consistent, the actual content of each particle size fraction is influenced by the nature and intensity of land use practices. Such variation, even within the same textural class, could affect important soil physical properties such as porosity, permeability, compaction, water retention capacity, and nutrient availability. This aligns with previous studies which have shown that continuous land use changes can lead to noticeable shifts in soil particle distribution over time (Osuji *et al.,* 2010; Olorunfemi *et al.,* 2021).

Table 1: Spatio-temporal changes of FUNAAB in 2005, 2015 and 2025.

Change Period	Vegetation		Wetland		Waterbody		Built up		Bare land	
	(sqkm)	%	(sqkm)	%	(sqkm)	%	(sqkm)	%	(sqkm)	%
2005-2015	-42.2	-9.6	-34.8	-8.0	21.5	4.9	33.2	7.8	22.3	5.1
2015-2025	-23.1	-5.4	-77.1	-17.8	-17.5	-4.0	47.4	10.9	70.6	16.2
2005-2025	-65.3	-15	-111.9	-28.8	4.0	0.9	80.6	18.7	92.9	21.3

Table 2: Particle size analysis of the studied area at depth 0-15cm

Sample	Sand	Clay (g/kg)	Silt (g/kg)	Sample	Sand	Clay (g/kg)	Silt (g/kg)
1	594	315	101	14	631	258	121
2	675	214	121	15	591	278	140
3	655	214	141	16	631	258	121
4	655	234	121	17	695	214	101
5	652	258	101	18	692	258	61
6	614	214	182	19	652	258	101
7	695	214	101	20	692	217	101
8	551	258	202	21	611	235	162
9	614	214	182	22	695	214	101
10	634	214	162	23	672	237	101
11	652	258	101	24	672	258	81
12	695	214	101	25	695	214	101
13	655	214	121				

Textural class of the samples is Sandy Clay Loam

Descriptive statistics of the studied soil

Soil pH remains a central variable in assessing the effects of land use change on soil chemical properties, as it regulates key processes such as nutrient solubility, cation exchange, and microbial dynamics (Adebayo *et al*., 2024). In this study, soil pH values measured in distilled water and KCl showed consistent variation across the 25 sampling points. The pH in distilled water ranged from 5.80 to 7.35 with a mean of 6.67, while values in KCl ranged from 4.95 to 6.18 with a mean of 5.55 (Table 4). The lower values recorded in KCl indicate the presence of exchangeable acidity, commonly attributed to aluminum and hydrogen ions occupying exchange sites (Adekunle *et al*., 2023). The variation in pH was moderate, with coefficients of variation of 6.15% and 6.85% in distilled water and KCl, respectively.

The concentrations of exchangeable bases varied considerably. Calcium (Ca) and magnesium (Mg) had mean values of 3.8 cmol kg^{-1} and 1.7 cmol kg^{-1}, respectively. Potassium (K) and sodium (Na) recorded lower mean values of 0.2 and 0.3 cmol kg^{-1}. All exchangeable cations showed wide ranges and high variability among samples, possibly due to land use changes affecting nutrient retention (Umeh *et al*., 2024). Available phosphorus (P) concentrations ranged from 2.3 to 28.0 mg kg^{-1}, with a mean value of 6.5 mg kg^{-1}. This parameter showed the highest coefficient of variation (93.9%), indicating substantial heterogeneity among the soil samples. This may be because of spatial changes of land cover classes, surface runoff, and past land management practices such as fertilizer application or waste deposition (Chukwuma *et al*., 2023). Total nitrogen (TN) content ranged from 0.04% to 0.22%, with a mean of 0.10% (Table 3).

Soil organic carbon (SOC) had values between 0.51% and 3.91%, with a mean of

1.66% and a coefficient of variation of 52.4%. The relatively low organic carbon and nitrogen levels showed the extent of land use changes, especially in areas with reduced vegetative cover, compaction, or erosion. These conditions limit organic matter accumulation and disrupt natural nutrient cycle (Ibrahim and Falade, 2024). The observed variability in soil chemical properties aligns with differences in sampling locations and associated land use conditions (Table 4).

DISCUSSION

The study confirmed that land use changes significantly influenced the physical and chemical properties of soil within the Federal University of Agriculture Abeokuta area. The observations of Ibrahim *et al.* (2023), showed that conversion to built-up area and bare land recorded noticeable decline in soil quality, indicating loss of fertility. Similarly, evidence from related studies, such as in the Ganzer watershed, northwest Ethiopia, confirms that land use types significantly influence both the physical and chemical properties of soils (Molla *et al.,* 2022). Notably, parameters such as sand, silt, and clay content, organic carbon, pH, total nitrogen, available phosphorus, and exchangeable bases were all found to be altered across different land use types.

Table 3: Descriptive statistical properties of the studied soil

	pH (H_20)	KCl	Ca (cmol/kg)	Mg (cmol/kg)	K (cmol/kg)	Na (cmol/kg)	TN (%)	SOC (%)	P (cmol/kg)
Mean	6.67	5.55	3.8	1.7	0.2	0.3	0.1	1.66	6.5
CV	6.15	6.85	42.1	52.9	50	33	100	52.4	93.9
Median	6.68	5.53	3.5	1.2	0.2	0.3	0.1	1.45	4.9
Mode	6.68	5.45	-	-	-	-	-	-	-
SD	0.41	0.38	1.6	0.9	0.1	0.1	0.1	0.87	6.1
SV	0.17	0.14	2.4	0.9	0	0	0	0.76	37
Kurtosis	-0.52	-0.3	2.1	-1	0.4	0.3	0.3	0.79	7.7
Skewness	-0.11	0.16	1.1	0.6	0.7	0.6	0.1	0.78	2.3
Range	1.55	1.23	6.6	2.5	0.4	0.4	0.2	3.46	26
Minimum	6.02	4.99	1.7	0.7	0.1	0.2	0	0.51	2.3
Maximum	7.57	6.22	8.3	3.2	0.5	0.6	0.2	3.97	28
Sum	167	139	95	42	5.7	7.8	3.2	41.4	162
Count	25	25	25	25	25	25	25	25	25

Abbreviation: CV, Coefficient of variation; SD, Standard deviation; SV, Sample Variance: pH, Hydrogen potential; Ca, Calcium; Mg, Magnesium; K, Potassium; Na, Sodium; TN, Total nitrogen; SOC, Soil organic carbon; P, Available phosphorus.

Furthermore, the marked reduction in pH values, particularly in soils from bare land and built-up area, suggested increased acidity levels. Conversely, wetland and vegetated areas maintained stable pH and nutrient levels, validating reports by Eze *et al.* (2023) that natural cover helps buffer soil reactions and improve cation retention. The observed variability in phosphorus and exchangeable bases reflects the inconsistency in land management practices across the area. The study also corroborates the conclusions of Nnaji *et al.* (2023), who stated that rapid land conversion without adequate conservation measures accelerates topsoil loss and fertility degradation. Therefore, there is an urgent need for improved land management and sustainable planning to preserve soil quality and agricultural potential across all landscapes.

CONCLUSION

This study revealed that land use changes significantly affect soil properties within the

Federal University of Agriculture, Abeokuta area. Over a span of 20 years, there has been a marked increase in built-up (94.6%) and bare land areas (25.6%), while vegetation (33.6%), wetland (16.8%), and waterbody (2.2%) have drastically declined. These changes had direct consequences on soil properties, thereby leading to variations in overall soil quality across the different land use types.

In view of these, the study concluded that appropriate land use act and the implementation of sustainable land management practices are crucial to abate further degradation. Without decisive and informed action, continued misuse will threaten agricultural productivity, food security, environmental resilience, and the overall health of soil systems.

REFERENCES

Adamasu, D., Amede, T. and Mekonnen, K. 2014. Soil property changes under different land uses in the Ethiopian highlands. *Environmental Monitoring and Assessment*, 186(11): 7053–7065.

Adebayo, T. O., Adeoti, A. A. and Salawu, M. A. 2024. Soil pH variability under land use change in tropical zones. *International Journal of Soil and Environmental Research*, 18(1): 34–42.

Adekunle, A. F., Salami, A. O. and Kolawole, B. A. 2023. Assessment of soil acidity under varying land cover types in southwestern Nigeria. *African Journal of Soil Science*, 13(2): 88–97.

Adepoju, M. O., Oyinloye, M. A. and Akinbamijo, O. B. 2019. Urban expansion and land use dynamics in southwestern Nigeria: A geospatial approach. *Journal of Urban and Regional Planning*, 8(2): 57–70.

Adimassu, Z., Kessler, A., and Stroosnijder, L. (incomplete — year not specified). Effect of land use on soil properties in Ethiopian highlands.

Anderson, J. R. 1976. A land use and land cover classification system for use with remote sensor data. *US Geological Survey Professional Paper* 964.

Anthony, J. O. 2023. Analysis of land transformation within FUNAAB campus using remote sensing techniques. *FUNAAB Journal of Environmental Studies*, 6(1): 55–66.

Aredehey, E., Haileslassie, A. and Tilahun, M. 2019. Impact of land cover dynamics on soil nutrients in northern Ethiopia. *Soil and Tillage Research*, 194: 104–116.

Bahrami, H. A., Heidari, A. and Gholami, A. 2010. Land use effects on selected soil properties in north of Iran. *World Applied Sciences Journal*, 11(7): 845–851.

Bremner, J. M., and Mulvaney, C. S. 1982. Nitrogen-total. In A. L. Page (Ed.), Methods of Soil Analysis Part 2: Chemical and Microbiological Properties (pp. 595–624). *ASA and SSSA*.

Bununu, Y. A., Sule, S. O., and Olofin, E. A. 2023. Assessment of land use impacts on soil degradation in northern Nigeria. *African Journal of Environmental Studies*, 9(3): 211–225.

Chukwuma, O. J., Ezeh, A. O. and Emeka, P. E. 2023. Phosphorus variability in urban soils of southeastern Nigeria. *Nigerian Soil Science Journal*, 33(1): 45–55.

Day, P. R. 1995. Particle fractionation and particle-size analysis. In C. A. Black (Ed.), Methods of Soil Analysis. Part 1. Physical and Mineralogical Properties (pp. 545–567). *ASA and SSSA*.

Deng, X., Li, Y. and Wang, M. 2024. Human-induced land use changes and their impact on ecological systems: A global review. *Land Degradation and Development*, 35(2): 101–115.

Ekanade, O. 2007. The influence of geology on soil formation and vegetation pattern in southwestern Nigeria. *Geoscience Review*, 8(2), 75–89.

Eze, P. N., Okeke, J. U. and Alika, J. E. 2023. Soil buffering capacity under various land cover types. *African Journal of Ecology*, 61(4): 583–591.

FAO. 2015. World reference base for soil resources 2014, update 2015. World Soil Resources Report No. 106. *Food and Agriculture Organization of the United Nations*.

Gbadebo, A. M., Ojekunle, Z. O. and Ajibola, A. A. 2023. Soil-landscape interactions in a university landscape: Evidence from FUNAAB, Nigeria. *International Journal of Soil Science*, 18(2): 77–89.

Gebreselassie, Y. and Ayanna, T. 2013. Effects of land use change on soil fertility and erosion in Ethiopia. *Journal of Environmental Science and Water Resources*, 2(4), 123–130.

Ibrahim, F. M. and Falade, S. A. 2024. Organic matter depletion in tropical soils affected by land transformation. *Nigerian Journal of Soil and Environmental Research*, 12(1): 91–100.

Ibrahim, M. O., Balogun, R. T. and Adeyeye, O. E. 2023. Urban encroachment and its influence on soil fertility: A case study from Abeokuta. *Journal of Sustainable Agriculture*, 19(3): 134–148.

MDPI. 2024. Soil and environmental changes in rapidly urbanizing zones. *MDPI Reports in Environmental Science*, 11(1): 56–69.

Molla, D., Taddesse, M. and Belay, T. 2010. Long-term cultivation impacts on soil properties in Ethiopia. *Journal of Agricultural Science*, 48(3): 329–338.

Molla, D., Taffese, S. and Getachew, B. 2022. The influence of land use types on selected soil properties in Ganzer Watershed. *Journal of Environmental Studies and Agriculture*, 14(2): 122–138.

Montanarella, L., Panagos, P. and Jones, A. 2022. Soil degradation as a global development challenge. *Nature Sustainability*, 5(2): 89–95.

Nayak, A. K., Sharma, A. and Rajput, S. 2024. Land use transitions and their impact on soil quality in South Asia. *Environmental Monitoring Letters*, 19(2): 201–218.

Nnaji, N. A., Ezeh, C. I. and Ukaegbu, M. E. (2023). Soil quality under land use transition in southeastern Nigeria. *International Soil Research Journal*, 13(3): 199–210.

Ojekunle, Z. O., Akinyemi, B. A. and Olatunji, O. F. (2023). Topographical and pedological mapping in FUNAAB campus. *Nigerian Soil Science Journal*, 15(4): 310–321.

Oke, D. O. and Adeyemi, A. A. 2019. Vegetation patterns in response to urban development in Ogun State. *Nigerian Journal of Botany*, 32(1): 13–24.

Olorunfemi, M. O., Adebayo, J. A., and Bakare, K. T. (2021). Land management practices and soil structure in southwest Nigeria. *African Journal of Soil and Water Conservation*, 11(2): 65–74.

Olorunfemi, M. O., Adepoju, A. A., and Adeleke, S. A. 2018. The impact of land use planning on soil productivity in Nigeria. *Journal of Land Use Policy*, 70: 274–284.

Olsen, S. R., Cole, C. V., Watanabe, F. S. and Dean, L. A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate (Circular No. 939). *USDA*.

Osuji, G. E., Nnoke, F. C. and Ogoke, I. J. 2010. Changes in soil physical properties under different land uses in Imo State. *Nigerian Agricultural Journal*, 41(1): 34–41.

Paul, A. K., and Rashid, M. H. 2017. Integrating land use change modelling with precision agriculture for sustainable soil management. *International Journal of Agricultural Research*, 12(4): 211–220.

Shen, Y., Zhang, W. and Chen, H. 2023. Accuracy of supervised classification methods in tropical land mapping. *Remote Sensing Applications*, 22(1): 101–112.

Smith, A. M., Okafor, L. A. and Bakare, B. A. 2023. Randomized soil sampling strategies in land use studies. *Soil Research Bulletin*, 9(2): 44–52.

Soil Science Division Staff. 2017. Soil survey manual (Chapter 4). *USDA* Handbook No. 18.

Tesfahunegn, G. B., Tamene, L. and Vlek, P. L. G. 2011. Catchment-scale soil property variation and its link with land use and management. *Catena*, 85(1): 1–13.

Thomas, G. W. 1990. Exchangeable cations. In D. L. Sparks (Ed.), Methods of Soil Analysis: Part 3—Chemical Methods (pp. 159–165). *ASA and SSSA*.

Tobore, O. A., Ayinde, T. A. and Daramola, M. A. 2025. Soil type distribution in Ogun State: A geospatial analysis. *Nigerian Soil Review*, 16(1): 23–38.

Tobore, O. A., Okon, E. A. and Bello, F. I. 2021. Climatic variability and its impacts on land use within Abeokuta area. *Environmental Trends in Nigeria*, 7(1): 101–112.

Ufoegbune, G. C., Oyeku, O. T. and Oloruntade, A. J. 2010. Climate variability and land use in FUNAAB campus. *Nigerian Journal of Environmental Studies*, 3(1): 11–20.

Umeh, A. C., Alade, T. O. and Nwosu, J. E. 2024. Exchangeable base loss under varying land cover in southwestern Nigeria. *African Soil Fertility Journal*, 10(2): 119–129.

Walkley, A., and Black, I. A. 1934. An examination of the Degtjareff method for determining soil organic matter. *Soil Science*, 37(1): 29–38.

Yitbarek, T., Belliethathan, S. and Stringer, L. C. 2013. The impacts of land use change on soil fertility in the central rift valley of Ethiopia. *Sustainable Agriculture Research*, 2(4): 34–41.

Zhou, X., Li, M. and Tang, Y. 2021. Land use change and its impact on soil organic carbon: A global synthesis. *Geoderma*, 402, 115293.

Responses of three sizes of fluted pumpkin (*Telfairia occidentalis* [Hook] F.) seeds to different growth media

Edun, A. R. and Shittu, M. M.

Department of Plant Breeding and Seed Technology,
Federal University of Agriculture, Abeokuta, Ogun State Nigeria

ABSTRACT

The experiment was conducted to determine growth response of fluted pumpkin (*Telfairia occidentalis*) to selected germination media (sawdust, wood shaven, river sand and top soil), also to investigate the best seed size that will translate to vigorous seedling. This study was conducted between February and April 2021, in the Screen house of Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, Nigeria. Two varieties of fluted pumpkin, four growth media and three different seed sizes: large (45- 47 mm diameter, and 19-22 g weight), medium (40-41 mm diameter and 16-17 g weight) and small (37-38 mm diameter and 11-15 g weight), making twenty-four (24) treatments were laid out in factorial Completely Randomized Design (CRD) and replicated twice were used in this study. The variety was highly significant to days to first germination (DTFG), seed size was significant ($p \leq 0.05$) on days to first germination, dry weight and fresh weight, while growth media (GM) was significant ($p \leq 0.05$) on dry weight and highly significant ($p \leq 0.01$) on day to first germination. Medium seed size took least number of days to germinate and sawdust proved to be the best growth medium out of the three media. The medium seed size performed better (germinated more vigorously and grew to healthy plants) than other seed sizes. Hence, for optimum growth and vegetative yield of *T. occidentalis*, medium seed size of 40-41 mm diameter and 16-17 g weight from carefully selected variety and sawdust as a growing medium should be used to raise seedlings.

Key words: Fluted pumpkin, growth media, seed size

***Corresponding author**: edun.abayomir@student.funaab.edu.ng

INTRODUCTION

Telfairia occidentalis also known as fluted pumpkin but referred to as "Ugwu" by the Igbo in Nigeria belong to the family of cucurbitaceae. It is a creeping leafy vegetable with huge lobed leaves and long twisting tendrils (Onuguh *et al.*, 2022 and Osuji *et al.*, 2022).The plant is unisexual, a strong climber with grayish fruits embedded edible seeds that are smooth with hard seed testa (Schippers, 2000). The vegetable is commercially lucrative and grown throughout West Africa's lowland humid tropics, Sierra Leone, Ghana, and Nigeria being the leading producers. (Duling *et al.*, 2019). *T. occidentalis* seeds and leaves are consumed because they are healthy sources of lipids, vitamins, fiber, and minerals such as iron, potassium, phosphorus, and mineral salt (Obembe *et al.*, 2021). The seed of *T. occidentalis* is the only means of propagation. The seed is recalcitrant, hence losses its germination potentials within a short period of time after opening the pod, especially when the seeds are poorly developed due to biochemical transformation that usually occurred in the seed at different moisture levels (Tairu and Bolounduro, 2006). Due to high moisture content of the seeds, it cannot be stored for a long period of time and maintain viability (Tairu, 2003). One of the most important criteria for successful germination is a reliable growth medium. The influence of the medium is felt even before the plant sprout, because of its water retention and aeration properties. Locally and readily available materials such as wood shaven, sawdust, rice hull, river sand, coconut fibre and mixture of these materials have been proven to be a good media for germination of many crops (Ekwu and Mbah, 2001). But there is limited information on the relationship between growth media and seed sizes on germination and vigour of *T. occidentalis* (Ndor *et al.*, 2012). Therefore, there is need to study responses of three sizes of fluted pumpkin seeds to different growth media. The objective of this study is to identify the best growth medium and seed size for *Telfairia occidentalis* that will support establishment of healthy and vigorous seedlings.

MATERIALS AND METHODS

The experiment was conducted between February and April 2021, in the screen house of Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, Nigeria, in the rainforest agroecological zone of Southwest Nigeria, of Latitude 7°20´N and Longitude 3° 23´E. The experimental design was factorial in Completely Randomized Design (CRD), the treatments consisted of two (2) varieties of fluted pumpkin, three (3) different seed sizes (small, medium and large) of fluted pumpkin, four (4) germination media (wood shaven, sawdust, river sand and topsoil) and replicated twice. Forty-eight (48) labelled and pods were filled with the various growth media, watered sufficiently and left for 24hrs, excess water was allowed to drain. Two freshly harvested varieties of matured *Telfairia occidentalis* pods sourced from Calabar (CLFP), Cross River State and Iwoye-ketu (ILFP), Ogun State (Nigeria) were used.

The pods were opened, seeds were manually extracted, and mucilaginous coat of the seeds was carefully removed and rinsed with clean water. The seeds were spread on germination paper to absorb the surface moisture. Digital Vernier caliper and sensitive scale were used to measure the diameter (mm) and weight (g) of the seeds, respectively. The seeds were categorized into large (45-47 mm and 19-22 g), medium (40-41 mm and 16-17 g) and small (37-38 mm and 11-15 g). Five seeds were sown in different growth media (sawdust, wood shaven, topsoil and river sand) after 24 hours of extraction. The pots were watered every other day (48 hourly) in the early hour of the day.

The following parameters were assessed: days to first germination, percentage germination, seedling length, number of leaves per plant, fresh weight and dry matter content. The data collected were subjected to analysis of variance (ANOVA), means were separated using Tukey's at 95% confidence interval and correlation analysis.

RESULTS

Means square effect on days to first germination (DTFG), dry weight (DW), fresh weight (FW) and germination percentage (GP) of fluted pumpkin (*Telfairia occidentalis*) seeds of different sizes on different growth media (Table 1). Variety was highly significant ($p \leq 0.01$) on days to first germination (DTFG), seed size was significant ($p \leq 0.05$) on DTFG, dry weight (DW) and fresh weight (FW), whereas growth media was significant on DTFG and DW. Mean performance on agronomic characters of fluted pumpkin (*Telfairia occidentalis*) of different seed sizes in different growth media (Table 2). Calabar variety (V_1-17.2) was significantly different from Iwoye-Ketu (V_2-14.13) in DTFG. Effect of variety on all other characters was not significantly different from each other. Significant effect of seed size was observed on DTFG, DW and FW. Medium seed size (S_2) had least days to DTFG (15.1), while Small seed size (S_3) recorded highest DTFG. Largest seed size (S_1) recorded highest FW and DW of 37.3 and 7.4 respectively, while S_3 had least FW and DW but S_2 was not significantly different from S_1 and S_2. There were no significant differences in mean performance of seed size of GP. The mean performance of growth media to DTFG revealed that topsoil (G_1) had least (13.1) while wood shaven (G_3) recorded least (18.6). There were no significant differences in FW (27.1-37.1) and GP (91.7-100) with respect to growth media. However, G_4 had highest DW (8.42) compared to G_3 (4.82).

Correlation of different seed size of fluted pumpkin (*Telfairia occidentalis*) on different growth Media (Table 3) showed that there was significant positive and negative correlation among many of the agronomic characters. It was obvious that germination percentage was not correlated to both number of leaves and seedling length at all level of collection.

Means square effects of number of leaves of fluted pumpkin (*Telfairia occidentalis*) seeds of different sizes on different growth media (Table 4). It was also observed that variety was significant ($p \leq 0.05$) on number of leaves at day 24 and 29, seed size (SS) was significant ($p \leq 0.05$) on number of leaves at day 34 while germination media was highly significant ($p \leq 0.01$) on number of leaves at day 19 and day 24. There was no significance effect on the interactions among the treatments. Effect of seed size on leaf production of fluted pumpkin (Figure 1) revealed that, there was no significant difference except at 34 days after planting, whereby S_2 had highest numbers of leaves and S_3 recorded the least leave number. Effect of growth media on seedling length in fluted pumpkin revealed that at day 19, 24 and 29, G_1 produced significant longest seedling length while G_3 at 19, 24 and 29 day after planting produced shortest seedling length. At day 34 and 53, G_2 produced longest seedling length which is statistically the same with G_1, G_3 produced shortest seedling length respectively, but at day 53, G_4 produced seedling length that was statistically the same with G_1 and G_2.

Table 2: Mean performance on agronomic characters of fluted pumpkin (*telfairia occidentalis*) seeds of different seed sizes in different growth media

Treatment	DTFG	DW (g)	FW (g)	GP
Variety				
V1	17.2a	6.90a	36.2	93.8
V2	14.13b	5.90a	29.8	97.9
Seed Size				
S1	15.2ab	7.40a	37.3a	93.8a
S2	15.1b	6.89ab	35.0ab	96.9a
S3	17.0a	4.91b	26.8b	96.9a
Growth_Media				
G1	13.1c	6.82ab	36.9a	95.8a
G2	15.8b	5.55ab	30.9a	100.0a
G3	18.6a	4.82b	27.1a	91.7a
G4	15.5b	8.42a	37.1a	95.8a

Mean followed by the same letter in each column are not significantly different at 5% level of probability ($p \leq 0.05$) using Tukey's. DTFG=, FW= Fresh weight, DW= Dry weight, GP= Germination percentage. V_1= Calabar local fluted Pumpkin (CLFP), V_2= Iwoye ketu Local Fluted Pumpkin (ILFP). S_1= Larger seeds; S_2= Medium seeds; S_3=Smaller seeds. G_1= Topsoil; G_2= Sawdust; G_3 = Wood shaven; G_4= River sand

Table 1: Mean square of effects of seed size and growth media on agronomic characters in two varieties of fluted pumpkin (*Telfairia occidentalis*)

Source of variation	DF	DTFG	Dry weight(g)	Fresh weight (g)	GP
Variety (V)	1	96.333**	12.000 ns	501.2 ns	208.3ns
Seed size (SS)	2	18.812*	27.602*	485.6*	52.1 ns
Growth media (GM)	3	60.833**	29.880*	285.4 ns	138.9 ns
V × SS	2	5.021ns	1.983 ns	55.8 ns	364.6 ns
V × GM	3	8.389 ns	17.889 ns	356.3 ns	69.4 ns
SS × GM	6	4.479 ns	2.502 ns	23.0 ns	191.0 ns
V × SS × GM	6	2.743 ns	2.705 ns	56.1 ns	225.7 ns
Residual	24	4.5	4.79	132.3 ns	208.3 ns
Total	47				

** Significant at $p \leq 0.01$, * Significant at $p \leq 0.05$, ns: not significant, DTFG= Days to first germination, GP = Germination percentage

Table 3: Correlation of different seed size of fluted pumpkin (*Telfairia occidentalis*) on different growth Media

	DTFG	DW(g)	FW(g)	Germ%	NL@19	NL@24	NL@29	SL@19	SL@24	SL@29
DTFG	-									
DW (g)	-0.32*	-								
FW(g)	-0.30*	0.94**	-							
Germ%	-0.12	-0.14	-0.16	-						
NL @19	-0.74**	0.22*	0.24	0.14	-					
NL @24	-0.84**	0.25*	0.20*	0.2	0.70**	-				
NL @29	-0.79**	0.41**	0.39**	0.03	0.68**	0.80**	-			
SL@19	-0.83**	0.29*	0.25	0.15	0.70**	0.77**	0.67**	-		
SL@24	-0.85**	0.43**	0.37**	0.08	0.68**	0.80**	0.80**	0.89**	-	
SL@29	-0.79**	0.51**	0.49**	0.04	0.66**	0.75**	0.86**	0.94**	0.82**	-

5% (0.20 – 0.29) *= Significant, 1% (>=0.20) **=highly significant. DTFG=Day to first germination, DW=Dry weight, FW=Fresh weight, Germ_%=Germination percentage (%), NL=Number of leaves, SL=Seedling length

Table 4: Mean square effects of number of leaves of fluted pumpkin (*Telfairia occidentalis*) seeds of different sizes on different growth media

Source of variation	DF	NL @19	NL @24	NL @29	NL @34	NL @53
Variety (V)	1	11.02 ns	63.02**	27.00*	24.08 ns	4.69 ns
Seed size (SS)	2	6.75 ns	8.40 ns	6.81 ns	27.52*	40.40 ns
Growth media (GM)	3	30.08**	17.69**	15.06*	17.00 ns	20.80 ns
V × SS	2	2.08 ns	8.77 ns	7.56 ns	3.65 ns	0.81 ns
V × GM	3	2.19 ns	2.58 ns	4.07 ns	6.97 ns	11.91 ns
SS × GM	6	1.97 ns	2.06 ns	4.20 ns	0.44 ns	1.17 ns
V × SS × GM	6	2.92 ns	3.49 ns	4.45 ns	4.62 ns	11.20 ns
Residual	24	4.56	3.23	5.00	5.83	14.52
Total	47					

ns: not significant, ** significant at $p \leq 0.01$, * significant at $p \leq 0.05$, NL= number of leave

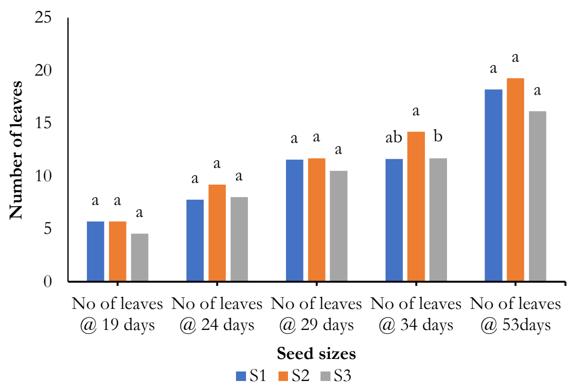


Figure 1: Effect of seed size on leaf production of fluted pumpkin

S_1= Larger seeds; S_2= Medium seeds; S_3=Smaller seeds.

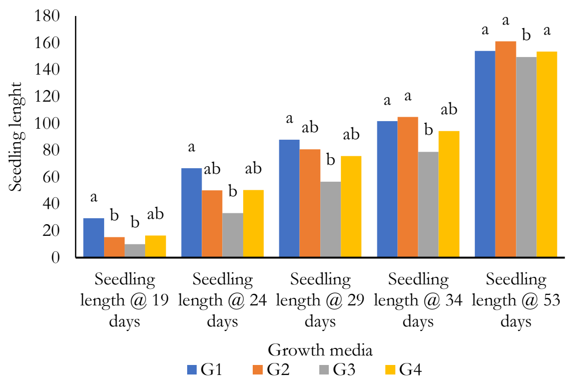


Figure 2: Effect of growth media on seedling length in fluted pumpkin

G_1= Topsoil; G_2= Sawdust; G_3 = Wood sheaven; G_4= River sand

DISCUSSION

The significant difference observed with topsoil and wood shaven, as compared with sawdust and river sand, in which topsoil took least number of days to germinate could be that there is good seed, nutrients, material contact and firmness, hence moisture availability to the seed, which was imbibed by the seed to trigger the germination. This agreed with work of Ekwu and Mbah (2001) who noted that materials like sawdust, river sand, rice hull, and their mixture allow seeds to sprout without forming a crust that will deter the seed from early sprouting. Sawdust significantly produced the distinct seedlings at day 34 and 53, which may be due to moderate retention of moisture and significant airspace. As reported (Maharani *et al*., 2010). The significant difference between germination of smaller and medium seeds on DTFG in which medium seeds germinated earlier could be that the medium seeds has enough stored energy and vigour to germinate. Sakpere, *et al* 2015 confirms that medium-sized seeds of *Telfairia occidentalis* .has enough reserve capacity and vigour to contributing to stronger emergence and survival in field conditions. Seed size have different levels of stance and other energy reserves, which may be an important factor to improve the expression of germination and initial grow of seedling (Shahi *et al*, 2015).

The best seedling length with **S_1** (large seeds) at day 53 as compared to S_2 (medium seeds) could be as a result of genetic makeup, the maintenance of continuous growth, nutrients release and vigor within during the period of observation over a period of time. This agrees with what (Adebisi *et al*., 2013) reported that large seeds have starch and nutrient than smaller seeds to support growth of seedlings. There was significant difference on number of leaves and seedling length at day 34, this could be influenced by the seed sizes. This trend agrees with Leishman *et al*., 2000 findings that seed size affects vigor, germination and seedling establishment. Small seeds (21.64 g) exhibited fastest initial vigor and growth performance in terms of vegetative production and dry biomass (Umeoka and Ogbonnaya, 2016). Smaller seeds had greater number of leaves at day 34. It is generally known that seedling seed sizes are the major factors influencing seedling emergence, stand establishment, and crop performance (Lamb and Johnson, 2004). The performance of any plant in terms of dry matter production is directly dependent on number of leaf and its development in response to solar energy and carbon dioxide perception.

CONCLUSION

Sawdust proved to be the best growth medium compare to the other media - topsoil, wood shaven and river sand, while medium seed size medium (40-41 mm diameter and 16-17 g weight) carefully selected from Iwoye-ketu local fluted pumpkin performed better than the smaller and larger seeds. However, for optimum growth and vegetative yield of *T. occidentalis*, sawdust should be used as growth medium.

RECOMMENDATION

This study examined response of *Telfairia occidentalis* to seed sizes, growth media and variety. It recommended for optimum germination and vegetative growth of *Telfairia occidentalis,* medium seeds size (40-41 mm) diameter and (16 - 17 g) weight from carefully selected variety in sawdust as growth medium or raising quality seedlings.

REFERENCES

Adebisi, M. A., Ojo, D. K. and Salau, A. W. 2013. Seed size effect on seedling vigour in tropical crops. *Journal of Agricultural Research and Development*, 13 (2): 45–52.

Duling, K., Sheehan, P. and Ong, J. Côte d'Ivoire; Cavendish Square Publishing, LLC: New York, NY, USA, 2019.

Ekwu, G. and Mbah, B. N. 2001. Effect of varying levels of fertilizer and some potting media on the Flowering response of Marigold. *Nigeria Journal of Horticulture*, 5: 105-109.

Lamb, K. E. and Johnson, B. L. 2004. Seed size and seedling depth influence on canola emergence and performance in the

Northern Great Plains. *Agronomical Northern Journal* 96: 454-461.

Leishman, M. R., Wright, I. J., Moles, A. T. and Westoby, M. 2000. *Evolutionary ecology of Seed size*, pp. 31-57, In: M. Fenner (ed) Seeds.

Maharani, R., Tamai, Y., Takashi, Y. and Terazawa, M. 2010. Scrutiny of Physical Properties of Sawdust from Tropical Countries Wood Species: Effect of Different Mills and Sawdust Particle Size. *Journal of Forestry Research*, 7(1): 20-32.

Ndor, E., Dauda, N. S. and Chammang, H.B. 2012. Effect of germination media and seed size on germination and seedling vigour of fluted pumpkin (*Telferia occidentalis*) Hook F. *International Journal of Agricultural Sciences* ISSN: 2167-0447 2 (3): 113- 115.

Obembe, O. M., Ojo, D. and Ileke, K. 2021. Effect of different drying methods and storage on Proximate and mineral composition of fluted pumpkin leaf, *Telfairia occidentalis*. Hook f. *J. Hortic. Postharvest Res*. 4: 141–150.

Onuguh, I. Ikhuoria, E. and Obibuzo, J. 2022. Comparative proximate analysis of *T. occidentalis* (fluted pumpkin) leaves sold in three different markets in Benin City, Nigeria. Int. *J. Agric. Anim. Prod.* 2: 7–12.

Osuji, E. E., Munonye, J. O., Olaolu, M. O., Onyemauwa, C. S., Tim-Ashama, A. C., Ibekwe, C. C., Obasi, I. O., Obike, K. C., Ebe, F. E., Onu, S. E., Obi, J. N., Izuogu, C. U., Orji, J. E. and Inyang, P. 2022. Econometric Analysis of Fluted Pumpkin Production in Nigeria: Empirical In Depth Analysis. *Journal of Agriculture and Crops*, 8(2): 105–114.

Sakpere, A. M., Ajayi, S. A. and Adelusi, A. A. 2015. Physiological significance of cotyledon reserves in seedling development of fluted pumpkin (*Telfairia occidentalis*). *Nigerian Journal of Botany,* 28(2): 205–210.

Schippers R. R. 2000. African Indigene Vegetable. An Overview of the cultivated species. Chatthan, U. K, NR/ACO. EU. Pp 34-38.

Shahi, C., Vibhuti, K. B., Bargali, S. S. and Bargali, S. 2015. How seed size and water stress affect the seed germination and seedling growth in wheat varieties. *Current Agriculture Research Journal*, 3(1): 60-68.

Tairu F. M. and Bolounduro A. 2006. Influence of organo-fertilizer on yield and pod quality of Fluted pumpkin (*Telfairia occidentais* Hook. F.) NIHORT Ibadan, In-house review meeting. Advantage of Environmental Biology 2: 113-115.

Tairu, F. M. 2003. Studies and Pod characters and Quality of fluted pumpkin, (*Telfairia occidentais*. Hook. F.). Proceeding of Horticultural Society of Nigeria of the 21st Annual Conf. held at Lagos polytechnic, Ikorodu, Lagos. Advantage of Environmental Biology 2: 113-115.

Umeoka, N., and Ogbonnaya, C. I. 2016. Comparative Studies on the Effects of Seed Size and Sowing Depth on the Performance of Fluted Pumpkin. *Journal of Food Processing and Technology*, 7(5).

Effects of different propagule type and watering regime on growth and yield of waterleaf (*Talinum fruticosum*)

[1]Ogundipe, O. O.*, [1]Salau, A. W., Hammed, L. A and [2]Olowe, V. I. O.

[1]Department of Horticulture, [2]Institute of Food Security, Environmental Resources and Agricultural Research, Federal University of Agriculture, Abeokuta, Nigeria

ABSTRACT

Water leaf (*Talinum fruticosum*) is an important vegetable consumed in Nigeria. An experiment was thus conducted to determine the effect of watering interval and different propagule type on the growth and yield of water leaf. The experiment was conducted in the screen house of Federal University of Agriculture Abeokuta (7°15'N, 3°23'E). Treatments were three watering intervals (daily, 2-days and 4-days interval) and three propagule types (root stock, main stem and lateral stem). The experiment was a 3 x 3 factorial in a completely randomised design with 3 replicates. Data were collected on plant height, numbers of branches, leaves, flowers and side branches as well as shoot fresh and dry weight. The data were subjected to analysis of variance and the significant means were separated using Least Significant Difference at 5% probability level. Results indicated that watering interval had significant effect at 5 and 6 WAP. Application of water at daily and 2-days interval produced plants that were significantly taller than others at 5 and 6 WAP. Also, daily water application encouraged more branches at 6 WAP and application at 2 and 4 days interval produced plants with significantly more leaves than others at 5 WAP. Also, water leaf plants raised from their root stock were significantly higher than others in height, numbers of branches, leaves and side branches. Also, plants raised from root stock had significantly highest shoot fresh and dry weight. Therefore, planting from root stock and watering at 2-days interval are recommended for propagation of water leaf.

Keywords: Propagule types, shoot fresh, shoot dry weight, water leaf, watering intervals

***Corresponding author**: ogundipeomotola65@gmail.com

INTRODUCTION

Water leaf (*Talinum fruticosum* (L.) Juss Schippers, 2000) is a perennial herb that belongs to the family Talinaceae. Its botanical synonyms with which it can be used interchangeably are *Talinum trianglare* (Jacq.) Willd, *Talinum crassifolium* (Jacq.) Willd, *Portulaca triangularis* Jacq. and Portulaca fruticosa L. It is commonly found in the humid tropics with its origin being Central Africa (Dominic and Bassey, 2016). It is an important leafy vegetable grown in Africa (Ndaeyo *et al.*, 2013; Efretuei *et al.,* 2022) especially in many countries of West and Central Africa (Akachukwu and Fawusi, 2015). It is cultivated abundantly in Cameroon and Nigeria (Akachukwu and Fawusi, 2015).

Water leaf is a popular vegetable that is consumed in the different parts of Southern Nigeria. Its leaves and tender stems are used to prepare soups eaten with the starchy main meal. It is also useful as feed supplement for poultry and pig (Agbaire, 2011). Though, regarded as an unconventional plant (Eze-Steven *et al.,* 2020); it is rich in essential nutrients like β – carotene, vitamin A, vitamin C and minerals including calcium, potassium and magnesium (Mensah *et al.*, 2008; Ezekwe *et al.,* 2001). It also contains flavonoids, alkaloids, saponins and nutrients beneficial for human health including crude protein, fat, fibre, ash, sodium, phosphorus among others. (Akindahunsi and Salawu 2005; Aja *et al.* 2010; Olowoyeye *et al.* 2022).

Water leaf is often propagated from stem cuttings which could be cuttings from its main stem and lateral stem also including its root stock. In a previous work by Atusa and Umeri (2024), the different stem cuttings emerged into new plants. Different watering regimes have also been reported to affect the yield of waterleaf (Oluwole *et al*., 2018; Efretuei *et al.,* 2022). However in the literature, there is scanty information on the response of water leaf raised from the different stem cutting types to different watering regimes schedules. This needs to be investigated.

MATERIALS AND METHODS

This experiment was conducted in screen house at the Teaching and Research Farm, Federal University of Agriculture, Abeokuta (7°15'N, 3°23'E), Ogun State, Nigeria from January to April, 2025. Top soil (0 – 15 cm) were collected from an area of land that is left fallow for three years using a core sampler and then bulked into a composite mix. The soil was steam-sterilized once and allowed to recover for two weeks before use (Choudhary *et al*., 2022) This soil was mixed with cured poultry manure at 10 t/ha (Uko *et al*., 2013). Samples of the soil and poultry manure were taken to laboratory for analysis. Plastic buckets that measured 22.2 cm, 7 cm and 22.4 cm in big-diameter, small-diameter and height were filled with 8 kg top soil. Water leaf were sourced from the wild and then portioned into the root stock, main stem and lateral stem at 7 cm long ensuring that that each cutting contained about 3 to 5 buds. It was planted at two cuttings per bucket and after emergence; they were thinned to one plant stand per bucket. Plants were allowed to establish before watering treatments were imposed (Assaha *et al*., 2023).

The treatments consisted of three watering regimes (daily, 2-days interval and 4-days interval) and three propagule types (root stock, main stem and lateral stem). The experiment was a 3 x 3 factorial with a Completely Randomised Design (CRD) containing three replicates. Data were collected weekly from 4 to 6 Weeks After Planting (WAP) on plant height, numbers of branches, leaves, flowers and side branches as well as shoot and dry fresh weight. The data were subjected to analysis of variance and the significant means were separated using Least Significant Difference at 5% probability level. There was no significant interaction and was not presented or used to explain the results.

RESULTS

The soil physical and chemical analysis is presented in Table 1. The soil used in this experiment was slightly alkaline with moderate total N, adequate phosphorus levels and low potassium levels. It is also low in organic carbon but high organic matter. The poultry manure used in this same experiment was slightly alkaline and contained 3.685% nitrogen of its weight with an adequate phosphorus and potassium. It is high in organic carbon and organic matter (Table 1).

The results indicate that there was increment in the height of water leaf from 4 to 6 Weeks after Planting (WAP) with significant ($p \leq 0.05$) effect of the treatment combinations occurring at 5 and 6 WAP. At 5 WAP, waterleaf plants that were raised from root stock produced the significantly ($p \leq 0.05$) tallest plants while those from the main and lateral stems produced the significantly ($p \leq 0.05$) shortest plants. Also, waterleaf plants that were watered daily and at 2-Days intervals produced the significantly ($p \leq 0.05$) tallest plants and those that were watered on 4-Days interval produced the significantly ($p \leq 0.05$) shortest plants. Also, the number of branches of water leaf was observed to increase from 4 to 6 WAP. At 4 WAP, water leaf plants that were raised from root stock produced the significantly ($p \leq 0.05$) numerous branches that were comparable to

Table 1: Pre-cropping analysis of soil and organic manure

Properties	Soil	Poultry manure
pH (H2O)	7.5	7.03
Total N (%)	0.199	3.685
Available P (mg kg-1)	18.72	18.64
Org. C%	0.878	40.1
Organic matter (%)	38.7	69.13
Ex. A mEq/100g	0.5	NA
Ex. Bases (cmol kg-1)		
Ca	0.308	36.112
Mg	0.345	8.125
K	0.506	26.652
Na	0.321	28.916
E.C µS/cm	NA	9060
Sand	84.8	NA
Clay	11.92	NA
Silt	3.88	NA
Textural class	Sandy clay	NA

those produced by plants raised from their lateral stem and the significantly ($p \leq 0.05$) least branches were produced by water leaf plants raised from the main stem. Watering regime and its interaction with the propagule type had no significant effect on the branch production at 4 WAP. However, at 6 WAP, water leaf plants that were watered daily produced the significantly ($p \leq 0.05$) highest number of branches compared to those that were watered at 2-days and 4-days interval which produced the significantly ($p \leq 0.05$) lowest branches. Furthermore, the effect of propagule type was not significant on flower production. However, there were significant differences in the number of flower per plants as a result watering. At 5 and 6 WAP, water leaf plants that were watered on 4-Days interval produced the significantly ($p \leq 0.05$) most flowers while the plants that were watered on 2-Days interval produced the significantly ($p \leq 0.05$) least flowers. In addition, the propagule type of water leaf had significant ($p \leq 0.05$) effect on the number of leaves only at 4 WAP when the plant raised from their root stock produced the significantly ($p \leq 0.05$) highest number of leaves. In the same way, watering regime affected the leaf production only at 5 WAP when the plants that were watered at 2-Days and 4-Days interval produced the significantly ($p \leq 0.05$) highest number of leaves. So also, waterleaf plants raised from the root stock had the significantly ($p \leq 0.05$) highest side branch (regrowth) at 7 and 8 WAP while those plants that were raised from the main stem and the lateral stem produced the significantly ($p \leq 0.05$) fewest side branch. The different watering regimes had no significant ($p \leq 0.05$) effect on the side branch production. The fresh and dry weight of water leaf was significantly ($p \leq 0.05$) highest in the plants raised from the root stock but lowest from the plants that were raised from the main stem. In the same way, water leaf that were watered at 2-Days and 4-Days interval produced the significantly ($p \leq 0.05$) highest fresh weight and those that were watered at 2-Days interval produced the significantly ($p \leq 0.05$) highest dry weight.

DISCUSSION

Water leaf plants that were raised from different propagule obtained a similar height at 4 WAP. This suggests that the different propagules of water leaf is capable encourage a similar early growth. Afterwards, root stock produced plants that were taller, with more branches, leaves and side branches. This negates the report of Atusa and Umeri (2024) who filed that the root stock did not emerge. It could be because the root stock were cut with few metres of stems containing at least 3 buds from which the new plants emerged. Also, it could be because the plants received same volume of water and thus were allowed to establish by bringing out many leaves before the watering regimes were imposed at three weeks after planting (Assaha *et al.*, 2022). This result corroborates the findings of Severino *et al* (2011) on *Jatropha curcas*. They reported that the plants that originated from the stem cuttings that were obtained from branch closer the base produced more buds, stems, and leaves than stem cutting obtained from branch from middle and apex part of the plant. This could be because most of the mineral elements that a plants needs are stored in the root (Roberts *et al.*, 2007). And plants that emerge from parts closer to the root region will be vigorous.

The fresh and dry shoot weight was higher among plants that originated from the root stock. As observed, the plants which grew taller with more branches, leaves and side branches produced higher fresh and dry weight. This is similar to the report of Atusa and Umeri (2024) that the plant with more leaves, branches and flowers produced higher fresh weight.

Water leaf plants at 4 WAP were comparable in height, branch and leaf production. This may be that watering at 3 WAP appeared to sustain and encourage a similar height of water leaf plants. This could be due to the fact that watering regimes were imposed at 3WAP and a week after, the soil was still able to hold water considered sufficient to encourage a uniform growth of all the plants. In furtherance, watering at daily and at 2-day intervals supported tallest plant. The luxuriant growth could be as a result of the intermittent of supply of water that supports more branch and height. However, improved growth of plants with 4-days application of water justifies the findings of Kramer and Boyer (2005) who reported that plants which show improved growth with a limited supply of water can be considered as drought tolerate. Also, water application at 2 and 4-days interval encouraged more leaf production. This supports the findings of Mustapha *et al.,* 2021 that water leaf will produce significantly more leaves with adequate manure application. In the same way, delayed water application encouraged more leaf and flower production and this could be a coping strategy to water stress (Oluwole *et al.*, 2018).

Fresh and dry shoot weight of water leaf was higher in plants with 2-days water application. This could be due to the fact that such plants do have a more leaf produced on taller stems. Put together, the stems and leaves are what is harvested in fresh shoot weight and dried into dry shoot weight. This result corroborates the results of Efretuei *et al.* (2022) and Assaha *et al.* (2023) that delayed water application is optimum for accumulation of fresh and dry weight yield in water leaf.

CONCLUSION AND RECOMMENDATION

This experiment has tried to establish the watering interval and propagule type that support the optimum growth and yield of water leaf. The conclusion is therefore based on the findings. It is concluded that water leaf should be planted from its root stock and watering should be done at 2-days interval for optimum yield.

Table 4: Fresh and Dry weight (g/plant) of water leaf (*Talinum fruticosum*) as influenced by propagule type and watering regime

Treatment	Fresh weight (g/plant)	Dry weight (g/plant)
Propagule type		
Root stock	132.4a	9.33a
Main stem	108.1b	6.45c
Lateral stem	116.2ab	7.53b
Lsd, 5%	18.37	1.489
Watering regime		
Daily	95.5b	6.35b
2-Days	139.5a	9.28a
4-Days	121.7a	7.67b
Lsd, 5%	18.37	1.489

Table 2: Plant height, Number of leaves and Number of Branches of water leaf (*Talinum fruticosum*) as affected by propagule type and watering regime

Treatment	Plant height (cm)			Number of branches			Number of leaves		
	4 WAP	5 WAP	6 WAP	4 WAP	5 WAP	6 WAP	4 WAP	5 WAP	6 WAP
Propagule type									
Root stock	15.4	29.37a	40.43	6.11a	16.11	20.44	68.8a	95.9	165.1
Main stem	12.46	25.36b	39.1	3.67b	13.59	18.26	47.7b	75.4	145.7
Lateral stem	14.33	25.46b	38.89	4.56ab	12.33	16.74	45.6b	69.9	136.4
Lsd, 5%	ns	3.069	ns	1.6	ns	ns	17.03	ns	ns
Watering regime									
Daily	12.31	27.02a	40.45a	3.7	11.7	15.96a	42.3	43.3b	130
2-Days	14.67	29.79a	41.28a	5.15	16.04	18.96b	60.9	97.9a	150.7
4-Days	15.2	23.38b	36.70b	5.48	14.3	20.52b	58.8	100.0a	150.7
Lsd, 5%	ns	3.069	2.532	ns	ns	2.95	ns	27.94	ns

ns – not significant, WAP – Weeks After Planting, Lsd – Least Significant Difference ($p \leq 0.05$).

Table 3: Effect of propagule type and watering regime on the numbers of flowers and side branches of water leaf (*Talinum fruticosum*)

Treatment	Number of flowers		Number of branches	
	5 WAP	6 WAP	7 WAP	8 WAP
Propagule type				
Root stock	5.07	15	7.44a	7.52a
Main stem	2.81	9.4	5.26ab	5.37ab
Lateral stem	3.04	10.7	4.11b	4.26b
Lsd, 5%	ns	ns	2.441	2.286
Watering regime				
Daily	1.78b	11.3a	4.52	4.78
2-Days	3.59ab	6.0b	5.37	5.74
4-Days	5.56a	17.8a	5.37	6.63
Lsd, 5%	2.38	8.41	ns	ns

ns – not significant, WAP – Weeks After Planting, Lsd – Least Significant Difference ($p \leq 0.05$).

REFERENCES

Agbaire, P. O. 2011. Nutritional and anti-nutritional levels of some local vegetables (*Vernomia amygdalina, Manihot esculenta, Telferia occidentalis, Talinum triangulare, Amaranthus spinosus*) from Delta State, Nigeria. *Journal of Applied Sciences and Environmental Management,* 15: 625 – 628.

Aja, P. M., Okaka, A. N. C., Onu, P. N., Ibiam, U. and Urako, A. J. 2010. Phytochemical composition of *Talinum triangulare* leaves. *Pakistan Journal of Nutrition,* 9(6): 527–530.

Akachukwu, M. F. and Fawusi, J. O. 2015. Nutrient Interactions in Soil. Handbook on soil science. 115.

Akindahunsi, A. A. and Salawu S. O. 2005. Phytochemical screening and nutrient-antinutrient composition of selected tropical green leafy vegetables. *African Journal of Biotechnology,* 4 (6): 497 - 501

Assaha, D. V. M., Awasume, A. C., Tabot. P. T. and Mfombep, P. M. 2023. Harvesting compounds the effect of water deficit on the Growth and yield of water leaf (*Talinum triangulare* (Jacq.) Willd.) *Journal* *of Tertiary and Industrial Sciences,* (3)2: 42–54

Atusa, K. and Umeri, C. 2024. Effect of different plant propagules and mulching materials on performance of water leaf (*Talinum triangulare*) in Delta state. African Education Indices, 13(1): 1–8.

Choudhary, M., Kajal Savita and Jat, H. S. 2022. Effect of steam sterilization on soil biological and chemical properties. *Journal of soil Salinity and Water Quality,* 14: 93 – 97.

Dominic, J. U., and Bassey, A. N. 2016. Crop Production and Soil Management Techniques for the Tropics. *Concept Publication Limited*: 297–303

Efretuei, A. O., Akpaninyang, F. E. and Ekwere, O. J. 2022. Effect of Different Watering Intervals on Water Leaf (*Talinum fruticosum*) Growth and Foliage Yield. *Journal of Agriculture and Food Sciences,* 6(2): 92 – 99.

Ezekwe, M. O., Besong, S. A. and Igbokwe, P. E. 2001. Beneficial influence of purslane and waterleaf supplement to human. Feder *Am Soc. Exp. Biol*, 16(4): 639.

Eze-Steven, P. E., Chukwuezi, F. O., Ebugozi, R. S., Dimejesi S. A. and Igwe, B. O. 2020. Qualitative and Quantitative Phytochemical Analyses of *Talinum triangulare* (Water leaf). *Journal of Applied Sciences,* 5(1): 14 - 21.

Kramer, O. and Boyer, O. A. 2005. An overview of plant water stress. *Journal of crop science*, 2(1): 20-27.

Mensah, J. K., Okoli, R. I., Ohaju-Obodo, J. O. and Eifediyi, K. 2008. Phytochemical, nutritional and medical properties of some leafy vegetables consumed by Edo People of Nigeria. *African Journal of Biotechnology* 7(14): 2304-2309.

Mustapha Y., Saleh H., Manu I. and Sanni B. 2021. Effect of plant spacing and cow dung rate on growth and yield of water leaf (*Talinum triangulare* Jacq.) in Gombe, Nigeria. 39th Annual Conference of Horticultural Society of Nigeria. 1326 – 1332.

Ndaeyo, N. U., Ikeh, A. O., Nkeme, K. K., Akpan, E. A. and Udoh, E.I. 2013. Growth and Foliar Yield Responses of Waterleaf (*Talinum triangulare* Jacq) to Complementary Application of Organic and Inorganic Fertilizers in an Ultisol. *American Journal of Experimental Agriculture,* 3(2): 324 - 335.

Olowoyeye O. J., Lawal I. K., Owolabi, O. A. Maraina, T. A. Abideem, A. A. and Olajide, O. F. 2022. Evaluation of phytochemicals property and nutritional composition of water leaf (*Talinum triangulare*) and Blood leaf (*Justicia carne*). *International Journal of Academic Health and Medical Research,* 6 (1): 126 – 135

Oluwole, S. O., Ogun, M. L. and Balogun, O. A. 2018. Effects of different watering regimes on the growth *Talinum triangulare* Jacq. *Journal of Research and Review in Science*, 5: 14 - 23.

Robert, B. J., Pockman, W. T., Hoffmann, W. A., Bleby, T. M. and Armas, C. 2007. Structure and Function of Root Systems. Imprint CRC Press 2nd Edition Pages24

Schippers, R. R. 2000. Africa Indigenous Vegetables. An Overview of the cultivated species. National Resources Institute/ Acp-EU Technical centre for Agricultural and Rural Co-operation, Chatham, United Kingdom. 214.

Severino, L. S., Lima, L. S., Lucena, M. A., Freire, A. O., Sampaio, R. S., Veras, R. P., Medeiros, A. L., Sofiatti, V., and Arriel, H. C. 2011. Propagation by stem cuttings and root system structure of Jatropha curcas. *Biomass and Bioenergy*, 35(7): 3160 – 3166.

Uko, A. E., Udo, I. A. and Shiyam, J. O. 2013. Effects of poultry manure and plant spacing on the growth and yield of waterleaf (*Talinum fructicosum* (L.) Juss). *Journal of Agronomy*, 12(3): 146–152.l

A review on effect of poultry manure rates on growth and yield of sesame (*Sesamum indicum* L.)

[1]Abbas, M. M.* and [2]Mohammed, A. K.

[1] Department of Agricultural Technology,
Federal Polytechnic Daura, Daura, Katsina State, Nigeria.
[2] Federal Polytechnic Monguno, Nigeria

ABSTRACT
This review focuses on the impact of different poultry manure rates on the growth and yield of sesame crop. The objective was to determine the optimal poultry manure rate that would result in the highest growth and yield parameters for sesame production. Various studies were analyzed to gather relevant information on this topic. The findings revealed that application of poultry manure significantly influenced the growth and yield of sesame crops. Among the different rates studied, Results revealed that the application of 15t/ha of poultry manure led to optimum growth and yield parameters for sesame plants. This rate not only produced maximum yield but also promoted significant growth in terms of plant height and leaf area. In contrast, the application of 5t/ha of poultry manure resulted in the minimum growth and yield outcomes for sesame crops. Plants treated with this lower manure rate exhibited reduced growth rates and lower yield production compared to those treated with higher manure rates.

Key words: Growth, poultry manure, sesame, yield,

***Corresponding author:** moduabbas@fedpolydaura.edu.ng

INTRODUCTION
Sesame (*Sesamum inducum* L.) also known as beniseed in West Africa, Sim-sim in East Africa is an oil crop belonging to the family *Pedaliaceae* grown in both tropical and sub-tropical regions of Africa, Asia and Latin America. It is the most important crop from which semi-drying vegetable oils are obtained and perhaps the oldest crop cultivated for its oil (Onwueme and Sinha, 1991). In 2007, Asia produced 2.4 million metric tons; Africa produced 1.2 million metric tons and Nigeria 110,000 metric tons of sesame (UN/FAO, 2008). Sesame is produced mainly in the savanna agro-ecological zones of Nigeria by small holders' farmers on relatively poor soils with limited inputs, thereby resulting in low average yield of 300 kg ha^{-1} compared with 1,960 kg ha^{-1} in Venezuela and 1,083 kg ha-1 in Saudi Arabia respectively (Abubakar *et al*., 1998). Sesame oil is considered to be of high quality oil and is often referred to as the "queen" of vegetable oil. This is due to its stability and high keeping quality as well as resistance to rancidity.

Sesame oil is used in the production of paints, soaps, cosmetics, perfumes, insecticides, canned sardine and canned beef as well as for pharmaceutical and ethno botanical uses (FAO, 2002; RMRDC, 2004). The whole seed is high in calcium, phosphorous, iron and are well supplied with essential vitamins such as thiamin, riboflavin and niacin. The whole seed is used on top buns and snack foods, fried and eaten with sugar, unfried or ground and used in making soup. The leaves are used for vegetable soup (Onwueme and Sinha, 1991). Traditional sesame growers in Nigeria rarely apply fertilizer on this crop because it is considered that it perform well even on poor soils (Haruna and Usman, 2005). However, nutrition studies in the tropics have shown that the crop perform well with the applications of organic or inorganic fertilizers (Haruna *et al*., 2011). Manure is a key fertilizer in organic and sustainable soil management. It contains many of the elements that are needed for plant growth and development. Apart from increasing soil fertility, manure serve as soil amendment by adding organic matter to the soil. Organic manure has also been reported to greatly improve water holding capacity, soil aeration, soil structure, nutrient retention and microbial activity (Anon, 2007) Manure application results in increased pH, water holding capacity and decrease in bulk density when used on long term basis (Anon, 2006).

Poultry manure application has been reported to improve crop performance in the study area (Ogbonna and Obi, 2007). Study conducted elsewhere has also shown that manure application promoted sesame yield (Suddhiyan *et al*., 2009). The enhancing effect of manure is attributed to the release of nutrient to the soil as well as improving the soil physical properties to the benefit of the crop (Mbagwu and Ekwealor, 1990). Manure also provides a gradual and more lasting release of a wide range of nutrient elements to the soil (Kroodsma, 1986). The objective of the study is to review the effect of poultry manure rates on growth and yield of Sesame.

Effect of Poultry Manure Rate on Plant Height of Sesame in Edo State, Nigeria 2009 and 2010

Application of poultry manure resulted significant effect on the plant height of sesame, where 10t/ha of poultry manure application gave the tallest plant in both 2009 and 2010. Followed by application of 5 t/ha of poultry manure while 0t/ha gave the shortest height in 2009 and 2010.

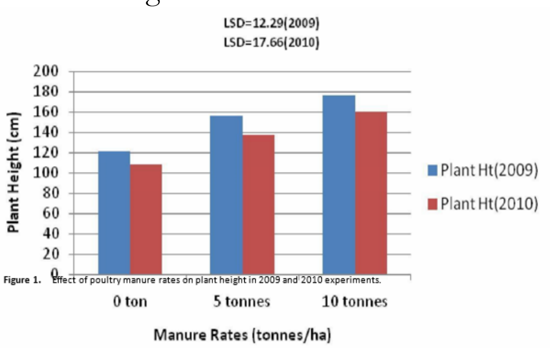


Figure 1. Effect of poultry manure rate on plant height of sesame at Edo State, Nigeria 2009 and 2010. Source: Yakubu and Okosun (2013).

Effect of Poultry Manure Rate on Number of Leaves per Plant of Sesame at Dadin Kowa, Gombe State

Application of poultry manure rate shows significant at 6 and 8WAS, where application of 4t/ha produced the highest number of leaves followed by 3t/ha while the least was recorded at 0t/ha. At 10WAS application 4 and 3/ha shows no significant among the treatment and produced the highest number of leaves follow by 2t/ha while the least was recorded at 0t/ha.

Table 1. Shows Effect of Poultry Manure Rate on Number of Leaves per Plant of Sesame at Dadin Kowa, Gombe State

Poultry manure t/ha	6WAS	8WAS	10WAS
0t/ha	21.3	29.1	42.9
1t/ha	24.3	30.2	45.8
2t/ha	25.1	32.2	50..9
3t/ha	26.1	37.1	57.3
4/ha	29.7	43.1	60.9
LSD	2.74	4.48	4.88

Source Usman *et al.* (2016)

Effect of Poultry Manure Rate on the Leaves Area Index of Sesame during the Rainy Seasons of 2005 and 2007 at Samaru

Table 2 showed every increase in the rate of poultry manure application significantly increased LAI of sesame in all years. The highest LAI was produced by the application of 15/ha of poultry manure at 4WAS after sowing, followed by application of 10/ha, while the least was recorded at 0t/ha in both in all years. Similar trend was observed at 6 and 8WAS.

Effect of Poultry Manure Rate on Number of Capsules, Capsule Length, and Yield of Sesame at Dutse in 2017 and 2018 Jigawa State, Nigeria

Application of poultry manure had significant effect on the number of capsules per plant of sesame in both seasons. In 2107, application of 15t/ha of poultry manure resulted in highest number of capsules while 5t/ha gave the lowest number and similar trend was observed in 2018 (Table 3).

Table 2. Shows Effect of Poultry Manure Rate on the Leaves Area Index of Sesame during the Rainy Seasons of 2005, 2006 and 2007 at Samaru

Poultry manure t/ha	4WAS			6WAS			8WAS		
	2005	2006	2007	2005	2006	2007	2005	2006	2007
0	0.17d	0.13d	0.11d	0.23d	0.25d	0.16d	0.50d	0.39d	0.26d
5	0.25c	0.20c	0.17c	0.51c	0.39c	0.26c	0.87c	0.67c	0.53c
10	0.31b	0.24b	0.22b	0.60b	0.46b	0.32b	1.07b	0.82b	0.69b
15	0.34a	0.27a	0.25a	0.67a	0.52a	0.37a	1.35a	1.04a	0.91a
SE	0.006	0.005	0.004	0.011	0.008	0.006	0.022	0.02	0.02

Source: Haruna (2011)

Table 3. Shows effect of poultry manure rate on number of capsules, capsule length, and yield of sesame at Dutse in 2017 and 2018 Jigawa State, Nigeria

Poultry rate t/ha	Number of capsules		Capsule length		Yield	
	2017	2018	2017	2018	2017	2018
5	65.13	62.7	2.8	2.93	446.33	752.1
10	103.2	65.1	3.12	2.96	496.13	865
15	120.8	78.7	3.15	3.1	533.67	865.9
SE±	8.34	6.87	0.01	0.1	99.44	94.8

Source: Danmaigoro *et.al.* (2020)

Poultry manure on capsule length of sesame was significant. In 2017, Application of 10 and 15t/ha of poultry manure was statistically similar on capsule length of sesame and 5t/ha gave the shortest length. In 2018, however application of 15t/ha of manure gave the longest capsule length while application of 5 and 10 t/ha was statistically similar on capsule length. Poultry manure application was not significant on the yield of sesame in both 2017 and 2018.

CONCLUSION

In conclusion, the review on the effect of poultry manure rates on growth and yield parameters has shown that different rates of poultry manure application can significantly impact plant growth and yield. The study found that the application of 15t/ha of poultry manure resulted in the highest growth parameters, indicating that higher rates of manure can promote better plant growth. On the other hand, the application of 10t/ha of poultry manure produced the maximum yield parameters, suggesting that there is an optimal rate of manure application for maximizing crop yield. While the lowest growth and yield parameters were recorded with the 5t/ha of poultry manure, this review indicate the importance of using adequate amounts of manure to achieve desirable outcomes in crop production.

Effect of Poultry Manure Rate on Grain Yield of Sesame at Keffi in 2008 and 2009 Nasarawa State, Nigeria

Application of poultry manure show significant differences. Where application of 10t/ha produced the highest yield followed by 5t/ha where the least obtained at 0t/ha in both 2008 and 2009.

Table 4. Shows Effect of Poultry Manure Rate on Grain Yield of Sesame at Keffi in 2008 and 2009 Nasarawa State, Nigeria

Poultry manure t/ha	Grain yield	
	2008	2009
0t//ha	1134.35c	1191.06c
5t/ha	1339.35b	1406.32b
10/ha	1914.07a	1933.20a
SE	3.416	3.5867

Source: Haruna (2012).

The review suggest that the application of poultry manure at a rate of 10t/ha can effectively enhance the growth and yield of sesame crops, providing a sustainable and cost-effective approach for farmers to improve crop productivity.

REFERENCES

Abubakar, S. S., Onyibe, J. E. and Tologbonshein, E. B. 1998. The role of extension Research and information dissemination in enhancing beniseed production Production, marketing of resource poor farmers. Proceedings of the First Workshop on Beniseed held at the National Cereal Research Institute, Badegi, Nigeria, March 3rd – 5th, 1998. Pp86-9

Anonymous, 2006. Fertilizer use by crops in Zimbabwe, FAO/UN, Rome. 55.

Anonymous, 2007. Effect of organic and inorganic nutrient sources on soil mineral Nitrogen and maize yields in Western Kenya. http://www.agnet.org

Danmaigoro, O., Zamfara, M. I.., Yakubu, H. and Musa M. U. 2020. Effects of poultry manure and weed control methods on growth and yield of sesame varieties. *Journal of Science*, 4: 8-15.

FAO (Food and Agriculture Organization of the United Nations. 2002. Sesame Production Information. http://www.ecoport.org/EP.exeSEntFull?ID=1937

Haruna, I. M. and Usman, A. 2005. Agronomic practices that enhances increased yield and seed quality of sesame (*Sesame indicum* L.). A paper presented at the: Agric. Transformation Day (sesame and rice) organized by OLAM Nig. Ltd. Held atAgro Millers Ltd. Compound, Uni-Agric. Road, Makurdi, 4th Feb., 2005.

Haruna, I. M., Ibrahim, H., & Rahman, S. A. (2009). The yield and Profitability of Roselle. (Hibiscus sabdarifffa L.) At varying poultry manure and nitrogen Fertilizer rates in the Northern guinea Savanna of Nigeria. Electronic Journal Of environmental and food chemistry. 8(11), 1136-1139.

I.M. Haruna., M.S. Abinmiku. Yield of sesame (*Sesamunm Indicum* L.) as influenced by organic fertilizers in the southern Guinea Savannah of Nigeria. Journal of Sustainable Agriculture Research Vol 1. Pp66.

Kroodsma, I. W. 1986. Treatment of livestock manure. Air dry and composted poultry manure. In: Odour Prevention and Control of Organic Sludge and Livestock Farming. The Netherlands. pp. 166-174.

Mbagwu, J. S. C. and Ekwealor, G. C. 1990. Agronomic potential of brewers spent grain. *Biol. Wastes*, 34: 335-347

Ogbonna, P. E. and Obi, U. 2007. Effect of time of planting and poultry manure application on growth and yield of sesame (*Sesamun indicum* L) in the deserved savannah agroecology. *Agro. Sc.*, 6(2): 3338.

Onwueme, I. C. aND Sinha, T. D. 1991. Field crop production in Tropical Africa. The Netherlands. 480pp.

RMRDC, 2004. Report on survey of Agro-Raw Materials in Nigeria Beniseed. Raw materials research and development council, Abuja, p. 99.

Suddhiyan P, Suwannaketnikom S, Dumkhum W, Duandao (2009). Fertilizer for organic sesame. Asian J. Fd. Agric.

UN/FAO, 2008. Regional sesame production, trade and consumption. United Nation /Food and Agriculture Organization. 5.

Usman, A., Ibrahim, A. k., Wakilli, A. and Abdull, I. 2016. Effect of pultry manure on growth and yield of sesame (*Sesamun indicum* L.) in Dadin-Kowa, Gombe State, Nigeria. Annual conference of the soil science of Nigeria (SSSN) 14-18, March 2016.

Yakubu A. and Okosun O. 2013. Resulting growth from the application of poultry manure and yield performance of accessions of sesame (*Sesamum indicum* L.) in a savannah transition zone of South eastern Nigeria. *International Journal of Manure and Fertilizer*, 2(9): 381-392.

Combined effect of staking and mulching on growth and yield of cucumber varieties

Onasanya, F. M. and Odedina, J. N.*

Department of Plant Physiology and Crop Production,
Federal University of Agriculture, Abeokuta.

ABSTRACT

The growth and yield of cucumber are vital parameters in measuring plant productivity, but agronomic practices such as staking and mulching also influence overall plant development. This study was carried out to assess the combined effect of staking and mulching on the growth and yield of cucumber (*Cucumis sativus* L.) varieties. The treatment consisted of variety: Daewy F1 and Darina F1 as the main plot and four combinations of staking and mulching: Trellis and mulch, Mulch, Trellis and no mulch and non-trellis as sub-plot. The experiment was laid in a split plot arrangement using a randomized complete block design, replicated three times. The objective of the study was aimed at assessing the individual and combined effects of staking and mulching on growth and yield of cucumber varieties. Growth parameters were: vine length (cm), stem girth (cm) and number of leaves per plant; Development parameters were: Days to first flowering, Days to 50% flowering and Days to maturity and yield parameters were: length of fruit (cm), weight of fruit (t/ha), diameter of fruit (cm) and total number of fruits per hectare. Data collected were subjected to Analysis of Variance using GENSTAT 12TH edition. Treatment means were separated using LSD at 5% probability level. Daewy F1 had significantly higher values in vine length, stem girth and number of leaves/plant compared to Darina F1. Trellis+mulch had the highest significant value in vine length and number of leaves/plant at 2, 4, 6 and 8 WAP compared to other treatments. Darina F1 flowered and matured earlier compared to Daewy F1. Daewy F1 had a higher significant fruit yield (kg/ha) compared to Darina F1. Trellis+mulch had highest significant fruit diameter, total number of fruits/ha, fruit yield (kg/ha) compared to other treatments. The fruit length obtained in trellis+mulch was significantly comparable to Trellis alone but significantly different from Mulch alone and the control (no mulch+no trellis). This finding showed the potential of low cost, sustainable agronomic practices which can enhance crop productivity. It can be concluded that Daewy F1 produced higher fruit yield (kg/ha) compared to Darina F1. Trellis+ mulch produced cucumber plants with the highest fruit yield (kg/ha) compared to the use of either trellis or mulch alone and the control (no mulch+no trellis).

Key words: Cucumber, mulching, staking

***Corresponding author**: odedinajn@funaab.edu.ng

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is a widely cultivated creeping vine of the Cucurbitaceae family, with slicing, pickling, and seedless types. Cultivated for over 3,000 years, it thrives in warm, humid climates. Asia dominates global cucumber production, with China alone producing 77% (FAO, 2022). In Africa, Egypt leads, while Nigeria's data is scarce despite growing demand. Low yields in Nigeria are largely due to poor agronomic practices, including the use of unimproved varieties, inadequate fertilizer application, poor staking, and limited irrigation (Okafor *et al.*, 2021). The optimum day temperature requirement is 30ºC, and optimum night temperature is 18-21ºC. Cucumber needs abundant amount of water but waterlogging is not suitable for its growth. Low humidity causes loss of water because of its large leaf area. The soil should be fertile, with good amount of organic matter, well-drained with a pH of 6.0-7.0. Economically, it supports food security and income generation (Adeoye and Balogun, 2016).

Improved practices like staking significantly boost cucumber yield and fruit quality (Modupeola *et al.,* 2016). Staking, although not directly suppressing weeds, but makes the plants more organized therefore, facilitating weeding operations and reducing damage to the cucumber plants during weed control. Staking has also been shown to improve marketable yield of cucumber. Staking significantly increases fruit yield, size and the overall plant vigour in field grown cucumbers under humid tropical conditions (Obasi *et al.,* 2022). Mulching is defined as applying any organic materials and or synthetic materials to partially or fully cover soil beds (Fahrurrozi, 2018). According to Lamont (2005), mulch modifies the growing environment, especially in the rhizosphere, through conservation of soil moisture, preventions of nutrient leaching and soil compacting, reduction of pest and pathogen attacks and suppressing of weed growth and development.

Mulching aids in regulating the soil temperature and act as a barrier for suppressing weed emergence. To prevent loss of soil moisture, to control weeds by shading them and diseases by preventing soil contact with the plant foliage, to control soil temperature, either by keeping it cool or keeping it warm, to add to soil fertility and increase soil organic matter content when organic mulch is used and decay takes place. Staking and mulching, when combined, have shown potential benefits for improving yield but are under-researched in Nigeria (Okafor and Yaduma, 2021). Many studies have shown that mulching improves the growth and yield characters of cucumbers. The integration of staking and mulching offers potential for enhancing cucumber yield, but their combined effect has not been thoroughly studied in Nigeria. In a study by Ogunbamiro *et al.,* (2014) cucumbers that were staked and mulched produced significantly higher yields and better quality compared to those with either of the agronomic practices alone. The interaction of staking and mulching has been found to influence the microclimate conditions such as humidity and soil temperature around the plant canopy and root zone, therefore creating a favourable environment for growth (Enujeke, 2013). These agronomic practices are essential in a climate smart and sustainable agriculture system as they improve resource use efficient and are ecosystem friendly (FAO, 2015).

Several methods have been used to increase the yield of cucumber. While staking and mulching have been studied individually there is a limited research on the combination of these agronomic practices with Daewy F1 and Darina F1. Therefore, more studies are required on the use of staking methods and application of mulch in Nigeria to determine how the application of staking and use of mulch affects the growth and production of cucumber. These studies will provide insights into the interactions between the two practices to optimize cucumber production. This study evaluates the combined effect of staking and mulching on growth and yield of cucumber varieties, focusing on two hybrid varieties: Daewy F1 and Darina F1.

MATERIALS AND METHODS

A field experiment was conducted at the FADAMA of the Federal University of Agriculture, Abeokuta, Ogun State. The experiment consisted of a plot size of 2 m by 2 m with a total of 24 plots. The experiment treatments consisted of two varieties of hybrid cucumber: Daewy F1 and Darina F1 as main plot. Staking and mulching as sub-plot: Trellis and mulch, Trellis, mulch, No mulch and No trellis (control). The experiment was laid out in a split plot arrangement in randomized complete block design and replicated three times. Dried guinea grasses were applied two inches above ground level per plant for mulch. Bamboo poles for staking.

Soil sample collection and analysis

A representative soil samples was taken with an auger at different location, specifically from the depth of 0-15 cm to determine the physical and chemical properties of the soil. The particle size analysis showed that the textural class of the soil was sandy loam with the pH of 6.60 which was slightly acidic to neutral this value is considered optimal for cucumber production.

Cultural practices

The land used was cleared manually. Application of pre-emergence herbicide (glufosinate ammonium) a non-selective contact herbicide with some systemic action at the rate of 1.5 L/ha was used. One seed was sown per hole on the 8th of February, 2025.The plant spacing used was 1m by 1m. Supplying was carried out one week after germination of seedlings on the 15th of February, 2025. Staking and mulching was applied two weeks after planting on the 22nd of February, 2025. Weeding was done manually with the use of hoe three and six weeks after planting. Pesticide application as Neem leaf extract was used as an insecticide and for pest and fungal control, having azadiracthin has its active ingredient, it was applied at two weeks after planting then repeated every ten days till the onset of fruiting. NPK 15:15:15 was applied at the rate of 150 kg/ha as fertilizer during the third and sixth weeks after planting.

Data collections

Three stands of cucumber plants were selected from each plot, tagged and used for data collection which commenced from the second till the eight week after planting. Growth parameters were: vine length (cm), stem girth (cm) and number of leaves per plant; Development parameters were: Days to first flowering, Days to 50% flowering and Days to maturity and Yield parameters were: length of fruit (cm), weight of fruit (t/ha), diameter of fruit (cm) and total number of fruits per hectare.

Statiscal analysis

Data collected were subjected to Analysis of Variance using GENSTAT 12TH edition. Treatment means were separated using LSD at 5% probability level.

RESULTS

Physical and chemical analysis of soil before planting

The pH value (6.60) which was slightly acidic was optimum and the percentage of Total nitrogen (0.26%) recorded for the soil used for the study was moderate for *Cucumis sativus* production (Table 1). The soil used was sandy loam.

Effects of staking and mulching on growth of cucumber variety

The effects of staking and mulching and varietal differences on vine length stem girth and number of leaves per plant of cucumber at 2, 4, 6 and 8 WAP are presented in Table 2. Varietal difference had significant effect on vine length, stem girth and number of leaves per plant at 2, 4, 6, and 8 WAP. Daewy F1 had significantly higher values in vine length, stem girth and number of leaves/plant compared to Darina F1. Application of mulching+staking significantly differed in vine length, stem girth and number of leaves/plant of cucumber at 2, 4, 6 and 8 WAP. Trellis+mulch had the highest significant value in vine length and number of leaves/plant at 2, 4, 6 and 8 WAP compared to other treatments. Stem girth of cucumber obtained from Trellis+mulch was significantly comparable mulch and Trellis alone at 6 and 8 WAP.

Interaction of staking and mulching on growth of cucumber variety

The interaction of Daewy F1 and Trellis+mulch significantly had the longest vine length at 2 WAP compared to other treatments (Table 3). Thickest stem girth and highest number of leaves/plant of cucumber was observed in Daewy F1 and Trellis+mulch which were significantly different from other treatments.

Table 1: Pre-planting chemical and physical properties of the soil used for the study in 2025

Properties	Values
pH(1:2 H_2O)	6.60
N (%)	0.26
Org. C (%)	0.64
Org. M (%)	4.19
Av. P (mg/kg)	21.11
Ex. A (mEq/100g)	0.61
Na (cmol/kg)	0.33
K (cmol/kg)	0.52
Ca (cmol/kg)	0.31
Textural class	Sandy loam
Mg (cmol/kg)	0.35
Fe (mg/kg)	211.63
Cu (mg/kg)	3.10
Mn (mg/kg)	3.12
Zn (mg/kg)	2.38

Effects of staking and mulching on development of cucumber variety

Table 4 presents the effects of staking and mulching and varietal difference on the development of cucumber plants. Darina F1 was significantly different from Daewy F1 in days to 1st flowering, 50% flowering and days to matuirty. Darina F1 flowered and matured earlier compared to Daewy F1. Staking and mulching had a significant difference on days to 1st flowering and days to maturity on cucumber plants. Values obtained from Mulch alone were not significantly differenet from the control (no mulch+no trellis) in days to 1st flowering but were significantly different compared to other treatments. The control (no mulch+no trellis) was significantly different from other treatments in days to maturity. No significant difference was observed in the interaction of variety × staking + mulch of cucumber in days to 1st flowering, 50% flowering and days to maturity.

Effects of staking and mulching on yield of cucumber variety

Table 5 presents the effects of staking and mulching and varietal differences on fruit weight per plant, fruit length, fruit diameter per plant, total number of fruit/ha and fruit yield in kg /ha. Daewy F1 had a higher significant fruit yield (kg/ha) compared to Darina F1. Trellis+mulch had highest significant fruit diameter, total number of fruits/ha, fruit yield (kg/ha) compared to other treatments. The fruit length obtained in trellis+mulch was significantly comparable to Trellis alone but significantly different from Mulch alone and the control (no mulch+no trellis). There was no significant difference observed in the interaction of variety × staking+mulch in fruit length, fruit diameter, total number of fruit/ha and fruit yield.

Table 2: Effects of staking and mulching on growth of cucumber variety

Treatment	Vine length (cm)				Stem girth (cm)				Number of leaves per plant			
	2 WAP	4 WAP	6 WAP	8 WAP	2 WAP	4 WAP	6 WAP	8 WAP	2 WAP	4 WAP	6 WAP	8 WAP
Variety												
Daewy F1	27.25	67.79	109.23	171.67	2.25	4.01	4.67	4.91	7.33	11.58	20.25	32.23
Darina F1	25.17	58.83	101.88	141.67	1.95	3.01	4.32	4.66	5.58	9.92	17.23	28.33
LSD(0.05)	1.13	1.96	6.24	3.8	0.199	0.17	0.29	0.23	0.5	0.88	1.32	1.77
Staking +Mulching												
Trellis+Mulch	32.51	67.93	121.71	167.53	2.5	4.01	4.67	5.01	8.67	13.21	22.21	34.33
Mulch	25.33	64.43	105.22	162.52	2	3.83	4.52	4.83	5.67	10.33	19.17	30.17
Trellis	28.67	65.11	103.32	163.33	2.16	4.01	4.52	5.01	7.17	11.11	18.51	31.33
No mulch+No Trellis	18.33	55.77	91.32	133.33	1.75	3.52	3.66	4.33	4.33	8.67	14.83	24.83
LSD(0.05)	1.61	2.78	8.82	5.38	0.28	0.25	0.42	0.33	0.71	1.26	1.87	2.5
Interaction												
Variety*Staking +Mulch	2.273	NS	NS	NS	0.399	0.357	NS	NS	1.002	NS	NS	NS

Ns- Not Significant

Table 3: Interaction of staking and mulching on growth of cucumber variety

Variety	Staking+Mulching	Vine length (cm) 2 WAP	Stem girth (cm) 2 WAP	Stem girth (cm) 4 WAP	Number of leaves per plant (2 WAP)
Daewy F1	Trellis+Mulch	35.14a	3.01a	4.11a	10.33a
	Mulch	25.67bc	2.12b	4.01a	7.11b
	Trellis	30.12b	2.33b	4.01a	7.33b
	No mulch+No Trellis	18.33c	1.67c	4.01a	4.67c
Darina F1	Trellis+Mulch	30.12b	2.11b	4.01a	7.11b
	Mulch	25.14bc	2.12b	3.67b	4.33c
	Trellis	27.33b	2.11b	4.01a	7.01b
	No mulch+No Trellis	18.33c	1.83c	3.01c	4.01c
LSD (0.05)		2.27	0.39	0.36	1.00

NS – Not significant

Table 4: Effects of staking and mulching on development of cucumber variety

Variety	Days to 1st flowering	Days to 50% flowering	Days to maturity
Treatment			
Daewy F1	31.51	35.58	45.51
Darina F1	28.83	33.42	37.42
LSD(0.05)	0.62	2.07	1.12
Staking+Mulching			
Trellis+Mulch	29.17	33.67	40.51
Mulch	31.17	36.12	41.51
Trellis	28.67	33.17	40.67
No mulch+No Trellis	31.67	35.17	43.17
LSD(0.05)	0.881	NS	1.58
Interaction			
Variety*Staking+Mulching	NS	NS	NS

NS- Not significant

Table 5: Effects of staking and mulching on yield of cucumber variety

Treatment	Fruit weight per plant (g)	Fruit length (cm)	Fruit diameter (cm)	Total number of fruit/ha	Fruit yield (kg/ha)
Variety					
Daewy F1	259.01	20.67	4.59	31458	4642
Darina F1	229.11	19.17	4.782	29375	3665
LSD(0.05)	26.84	0.58	NS	NS	873.5
Stakng+Mulching					
Trellis+Mulch	307.91	22.33	5.28	40000	5964
Mulch	251.1	20.11	4.89	31250	3842
Trellis	276.41	21.51	5.19	27500	4669
No mulch+No Trellis	140.81	15.83	3.37	22917	2138
LSD(0.05)	37.961	0.827	0.3177	6196.1	1235.3
Interaction					
Variety*Staking+ Mulching	NS	NS	NS	NS	NS

NS- Not significant

DISCUSSION

The findings of the study showed that the combination of staking and mulching enhanced vegetative growth parameters such as vine length, stem girth and number of leaves. In this study the highest vine length, thickest stem girth and the highest number of leaves were obtained from the plot that Daewy F1 variety were planted on. Between the two cucumber varieties studied, Daewy F1 consistently exhibited superior performance over Darina F1 in terms of growth and fruit yield. This suggests that Daewy F1 possess inherent genetic trait that confers better adaptability and responsiveness to the combined agronomic practices (Okafor *et al.*, 2021).

The combination of trellis and mulching produced cucumber plants with the longest vine lengths, thickest stem girth and the highest number of leaves. This effect can be attributed to the complementary roles of both practices. By supporting the vines, staking improved the exposure of leaves to sunlight which facilitated photosynthetic efficiency. This aligns with findings by Obasi *et al.,* (2022)., who reported that staking significantly increased fruit yield, size and the overall plant vigour in field grown cucumbers under humid tropical conditions. Mulching conserves soil moisture, suppresses the growth of weed and regulates the soil temperature. According to Adewoyin *et al.,* (2022) mulched cucumber plants exhibited enhanced growth compared to no mulched plants. Darina F1 exhibited earlier development than Daewy F1 in terms of days to first flowering, days 50% flowering and days to maturity. This shows that Darina F1 had a faster growth cycle and Daewy F1 had a longer vegetative stage before transitioning into the reproductive stage. Plants that were trellised alone developed faster than trellised in combination with mulched plants, mulch alone and plants that were not mulched and trellised. The plants flowered earlier compared to mulch alone and the control. It was observed that staking alone was sufficient to promote early reproductive development of the plant. This can be due to the enhanced photosynthetic ability of the plant (Obasi *et al.*, 2022). Mulch alone, no mulch and no trellis plant had similar values. This indicated that they flowered later in comparison to the trellised plants. The agronomic practices of trellising and mulching enhanced the speed at which the cucumber plants transitioned from vegetative to reproductive growth and reached harvest readiness, less plant stress due to trellising which prevented the vines from trailing on the ground, and reduced pest and disease pressure. This can be due to improved light interception, air circulation and better photosynthetic efficiency thereby speeding up the transition to reproductive phases and conservation of soil moisture (Paulo *et al.,* 2003). Earlier maturity in trellised and mulched cucumber plants was good for early harvesting, with trellis and mulched cucumber plants performing better compared to no mulch and no trellis of the plants which affected the days to 1st, 50% and days to maturity. The highest fruit yield was recorded in the treatments where staking and mulching were combined. This can be attributed to the improved vegetative growth, better light absorption and reduced competition with weeds facilitated by these practices. The plots with plants trellised alone ranked second in yield performance followed by plots with plants mulched alone while no trellised and no mulched (control) plants produced the lowest yield.

CONCLUSIONS

It can be concluded that Daewy F1 produced higher fruit yield (kg/ha) compared to Darina F1. Trellis+ mulch produced cucumber plants with the highest fruit yield (kg/ha) compared to the use of either trellis or mulch alone and the control (no mulch+no trellis).

REFERENCES

Adeoye, I. B., and Balogun, O. L. 2016. Profitability and efficiency of cucumber production among smallholder farmers in Oyo State. *Journal of Agricultural Science*, 61(4): 387–398.

Adewoyin, O. B., Ajayi, E. O., and Omotayo, A. F., 2022. Effects of Effects of mulch and staking on the yield and post-harvest quality of cucumber (*Cucumis sativus* L.) in Southwestern Nigeria. *Nigerian Journal of Horticultural Science*, 26 (4): 88–96.

Enujeke, E. C. (2013).Economic evaluation of leaf and pod yields of *Telfairia occidentalis* produced by five different staking methods. IOSR *Journal of Agriculture and Veterinary Science* (IOSR), 4(3): 61-66.

Fahrurrozi, L., Suryani, and Sudjatmiko, S. 2018. Hasil Tanaman Mentimun Pada Berbagai Jenis Mulsa dan Kontruksi Ajir. Prosiding Seminar Nasional Hortikultura Indonesia, Bali, 240–246.

FAO. 2015. Food and Agriculture Organization of the United Nations (Climate-smart agriculture. Retrieved from https://www.fao.org/3/i3325e.pdf

FAO. 2022. Food and Agriculture Organization Statistics FAOSTAT for crops. Retrieved from http://www.fao.org/faostat/en/#data/QC/

Lamont, W. J. 2005. Plastics: Modifying the microclimate for the production of vegetable crops. *HortTechnology*, 16: 477–481.

Modupeola, T. O., Ajibola, A. T., Abdul-Rafiu, A. M., Dixon, H. G., and Akinleye, O. C. (2016). Effect of organic fertilizer and different staking methods on growth and yield of cucumber (*Cucumis sativus*). In Proceedings of 34th Annual Conference of Horticultural Society of Nigeria (pp. 420–427).

Obasi, M. O., Echezona, B. C., and Uzoho, B. U. 2022. Effect of staking and pruning on the growth and yield of cucumber (*Cucumis sativus* L.) in Southeastern Nigeria. *Journal of Agricultural Research and Development*, 22(1): 45-53.

Ogunbamiro, A. O., Adewoyin, O.B., and Ajayi, E, O. 2014. Effects of mulch and staking on the yield and post-harvest quality of cucumber (*Cucumis sativus* L.) in Southwestern Nigeria. *Nigerian Journal of Horticultural Science*, 26 (4): 123-131.

Okafor, B. N., and Yaduma, J. J. 2021. Soil and agronomic management for cucumber production in Nigeria. In IntechOpen. https://doi.org/10.5772/intechopen.96087

Paulo, S., Lima, S., Jailton, F. R., Jaedson, C. A. M., and Jaeverson, D. A. S. 2003. Plant density and fruit density of muskmelon. *Revista Brasileira de Fruticultura*, 25(2): 262–265.

Profitability analysis of wholesale mango marketing (*Mangifera indica*) in Igabi Local Government Area of Kaduna State, Nigeria

[1]Abdullahi, M.*, [2]Garba, A. A. and [3]Rabiu, A. M.

[1] Department of Agricultural Technology, Federal Polytechnic Daura. Katsina State. Nigeria
[2] Department of Mathematics and Statistics, Federal Polytechnic Nyak, Shendam. Plateau State,
[3] Department of Fisheries and Aquaculture, Federal University Dutsinma, Katsina State, Nigeria

ABSTRACT

This study analyzed the profitability of wholesale mango marketing in Igabi Local Government Area of Kaduna State, Nigeria. The specific objectives were to describe the socio-economic characteristics of mango marketers, determine the profitability of mango marketing, and identify constraints affecting wholesale mango marketing. Primary data were collected through a multistage random sampling technique from 100 respondents. Analytical tools used included gross margin analysis, marketing margin, and marketing efficiency ratios. Results showed that 72.2% of the respondents were male, 64.9% were married, and the majority (30.9%) fell within the age range of 30–39 years, with most having 6–10 years of marketing experience. The study revealed that mango marketing is profitable, yielding a gross margin of ₦314 and a cost–to–return ratio (CTR) of 1.09. Major constraints faced by marketers include poor road networks, price fluctuations, and inadequate storage. The study recommends the formation of cooperatives among marketers and the improvement of transportation infrastructure.

Key words: Mango, profitability, wholesale, marketing, constraints

***Corresponding author**: mohammedabdullahi@fedpolydaura.edu.ng

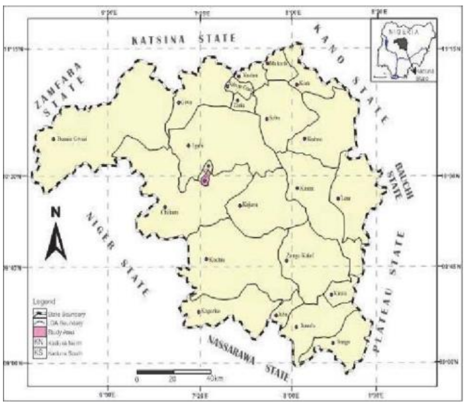
INTRODUCTION

According to the National Bureau of Statistics (2023), Nigeria's economy is mostly dependent on agriculture, which employs more than 35% of the workforce and accounts for over 25.58% of the country's GDP. Crops like rice, yams, cassava, sorghum, and maize are among Nigeria's main agricultural pursuits. Other activities include raising livestock, fishing, and forestry (FAO, 2022).The industry provides agro-industries with raw materials, revenue, and food. Nigeria's agricultural sector, however, confronts a number of difficulties despite its significance, including a low productivity, insufficient storage and infrastructure, limited financing availability, and the effects of climate change (Adebayo *et al.*, 2021). The effectiveness of agricultural marketing is greatly impacted by these limitations. In Nigeria, the activities involved in moving agricultural products from the farm to the end user are referred to as agricultural marketing. Sales, packaging, processing, storage, and transportation are all included (Olukosi and Isitor, 2005). Effective agricultural marketing is essential to the growth of agrarian economies, particularly for perishable goods like mangoes that need to be marketed quickly and effectively to avoid spoilage and losing value (Olayemi, 1998). A popular tropical fruit crop, mangos (*Mangifera indica*) offer substantial nutritional and financial advantages. Nigeria is a major producer of mangoes in Sub-Saharan Africa, with Kaduna State ranking among the top producers (FAO, 2021).Mango marketing in Nigeria is frequently limited by poor road infrastructure, high transportation costs, a lack of storage facilities, and asymmetric market knowledge, despite the fruit's high production potential (Afolabi, 2009). In addition to having an impact on marketers' earnings, these limitations also lower the efficiency of the mango value chain and increase post-harvest losses. To ensure that producers and marketers make a return from their investments and to encourage increased output, effective and lucrative marketing systems are necessary (Olukosi and Isitor, 2005). This study aims to assess the profitability of wholesale mango marketing in Igabi Local Government area of Kaduna State. The specific objectives include: describing the socio-economic characteristics of mango marketers, analysing the profitability of mango marketing, and identifying the constraints faced by wholesale mango marketers in the study area.

MATERIALS AND METHODS

Study area

This research was conducted in Igabi Local Government Area, Kaduna State, Nigeria. Kaduna State spans 46,053 km² with a population of approximately 6.1 million people (NPC, 2006). Igabi, situated within the state has a Latitudes of 10°471 N and Longitudes of 7°461 E with a population of around 180,860 people who relies heavily on agriculture (NPC, 2006). Key economic activities include maize production, poultry and fish farming, blacksmithing, and crop production (Alabi and Abdulazeez, 2018). It is also known for substantial mango production and feed for animal consumption this led to socio-economic growth (Alabi and Abdulaziz, 2018).



Source: (Abubakar *et al.*, 2018)

Sampling technique

A multistage random sampling technique was employed. Four districts were selected i.e. Amaza, Audi, Dutsen Mai, Garda, and 25 marketers were randomly chosen from each district, totaling 100 respondents (Philip, 2015). This approach was chosen to ensure that the sample was representative of the population while also being manageable in terms of size and logistics.

Data collection

The primary data was collected through structured questionnaires. Data collected were based on the socio-economic and demographic variables such as: sex or gender, age, farming experiences, educational status, household size, income level of the respondents, profitability variables, and factors hindering the mango marketing in the area of study.

Statistical Analysis

Data collected was analyzed using descriptive statistics and gross margin analysis. The descriptive statistics included data summaries in the form of frequencies and percentages presented in tables.

Analytical tools

a. Gross Margin (GM) is the difference between the total revenue earned from the sale of the mango and the total variable cost incurred in producing or marketing the mango, it indicate how much money is left after covering the direct cost of the business. The gross margin was used to measure the profitability of wholesale by each wholesaler, while variable cost included transportation, loading/unloading. Storage and market fees. A positive gross margin of N314 indicated that on average, wholesaler earned ₦314 per unit after covering their direct operating cost, showing that the business was profitable.

Total Revenue (TR) –Total Variable Cost (TVC) (Olukosi and Erhabor, 2008).

b. Cost–to–Return Ratio (CTR) is the cost to return ration measures the relationship between the total cost incurred and the revenue generated from an economic activity. It helps determine whether the mango business is profitable or not. The cost to return ration was calculated using below formulae to evaluate the overall the viability of mango marketing (Ojo *et al.*, 2011). $\frac{Total\ cost\ (TC)}{Total\ revenue\ (TR)}$ CTR > 1 means profitable, CTR=1: break even, and CTR < 1= loss

RESULTS AND DISCUSSION

The analysis of the socio-economic characteristics of mango marketers in Igabi LGA as shown in table 1 revealed a predominance of male participants (72%) and majority of the marketers fell within the age range of 30–39 years (31%) with 6–10 years of experience (42%). This suggest that mango marketing in the study area is largely dominated by relatively young and economically active males with moderate experience. This is consistent with the findings by Adepoju and Oyewole (2014) and Bappa (2008) who reported that due to the traditional belief, men in the Northern part of Nigeria engage in outdoor economic activities, while the women mostly stay in door as housewives, and partake micro enterprises. It also aligns with the earlier reports of Adenegan and Oladele (2014), who noted that fruit marketing in Nigeria is often dominated by males due to the physical demands of transportation and bulk handling. Similarly, Olorunsanya and Omotesho (2012) found that most agricultural marketers fall within the 30-40 year age group, indicating that marketing is driven by those in their most productive years. .Most respondents (65%) were married, which implies potential family support for their economic activities. Educational attainment among respondents showed that 85% had at least primary education, which is critical for understanding market information, pricing, and record-keeping (Akinbile, 2007). Furthermore, 58% of respondents belonged to cooperatives, highlighting the importance of collective action in accessing credit, inputs, and market information (Oladejo and Adetunji, 2012). Profitability analysis as indicated in table 2, showed an average gross margin of ₦314 per bag, with a cost-to-output ratio (CTO) of 1.09, indicating that for every ₦1 invested, ₦1.09 was realized, indicating a 9% return on investment which confirms profitability. This aligns with the results of similar studies of Adegeye and Dittoh (1985), who indicated that a CTR greater than one confirms profitability in agricultural marketing ventures. It also corresponds with the findings of by Yusuf and Mohammed (2017) in their analysis of orange marketing in Niger state, Nigeria, where they reported a gross margin of ₦289 and CTR of 1.12, suggesting fruit marketing generally yields positive returns. In contrast to Adebayo *et al.* (2016) in their study on banana marketing in Ekiti state reported a lower gross margin and a CTR of 0.94, implying a loss due to high transportation and spoilage cost. This discrepancy may be attributed to the perishability of bananas compared to mangoes or poor road infrastructure in that study area. However, marketers identified several constraints including poor roads, price fluctuations, and inadequate access to credit. These are common constraints noted in agribusinesses across Nigeria (Bello *et al.*, 2016). Thus, promoting cooperative societies, improving infrastructure, and facilitating access to soft loans will enhance marketing outcomes.

Profitability Analysis

The average gross margin was ₦314, indicating profitability. The cost–to–return ratio (CTR) of 1.09 means that for every ₦1.00 invested, ₦1.09 is earned, confirming a positive return on investment.

Constraints to Mango Marketing

Respondents highlighted poor road infrastructure, price fluctuations, and storage limitations as major challenges. These constraints are consistent with findings by Afolabi (2009), who noted that inadequate logistics significantly affect the efficiency of agricultural markets in Nigeria.

CONCLUSION AND RECOMMENDATION

Wholesale mango marketing in Igabi LGA is profitable, as shown by a gross margin of ₦314 and CTR of 1.09. Despite this, marketers face infrastructural and financial constraints. The following recommendations are made;

i. Mango marketers should form cooperative societies to increase access to financial and governmental support
ii. Government should invest in rural road infrastructure to improve market access.
iii. Training and provision of storage facilities should be considered to minimize post-harvest losses.

REFERENCES

Abubakar, A., Gobir, A., Ibrahim, I., Kusfa, I., Babalola, O., Alabi, O., Park, M., Kothari, S., Frimpong, J. and Nguku, P. 2018. Outbreak investigation of measles in Kaduna State, Northwestern Nigeria. *Pan African Medical Journal.* 30: 10.11604/pamj.supp.2018.30.1.15445

Adebayo, K., Akinola, M. O. and Ogunleye, T. A. 2016. Economic analysis of banana marketing in Ekiti State, Nigeria. *Journal of Economics and Sustainable Development,* 7(16): 110–116.

Adebayo, O. O., Adeola, R. G. Sulaiman, J. 2021. Constraints to agricultural productivity in Nigeria: *A review. Journal of Agricultural Economics and Development,* 10(2): 45–52.

Adegeye, A. J. and Dittoh, J. S. 1985. Essentials of agricultural economics. University of Ibadan Press.

Table 1: Socio-economic Characteristics of Respondents

Variable	Frequency	Percentage (%)
Sex		
Male	72	72.0
Female	28	28.0
Age Group		
< 20	5	5.0
20–29	18	18.0
30–39	31	31.0
40–49	27	27.0
50 and above	19	19.0
Marital Status		
Single	20	20.0
Married	65	65.0
Divorced	10	10.0
Widowed	5	5.0
Education Level		
No Formal Education	15	15.0
Primary	25	25.0
Secondary	35	35.0
Tertiary	25	25.0
Marketing Experience (Years)		
<1	8	8.0
1–5	20	20.0
6–10	42	42.0
>10	30	30.0
Belong to Cooperative		
Yes	58	58.0
No	42	42.0

Table 2: Profitability indicators of mango marketing

S/No.	Indicator	Value(₦)
1	Average Revenue	1,500
2	Total Variable Cost	1,186
3	Gross Margin	314
4	Cost-to-Return Ratio	1.09

Adekanye, T. O. (1988). Readings in agricultural marketing. Longman Nigeria.

Adenegan, K. O. and Oladele, A. A. 2014. Analysis of market structure, conduct and performance of kola nut marketing in Osun State, Nigeria. *Journal of Economics and Sustainable Development,* 5(21): 104–111.

Adepoju, A. A. and Oyewole, O. O. 2014. Gender and marketing of farm produce in Nigeria. *Journal of Agricultural Extension,* 18(2): 10-20.

Adewumi, M. O., and Adebayo, F. A. (2008). Profitability and efficiency of cassava marketing in Ibadan metropolis, Oyo State, Nigeria. *Journal of Human Ecology*, 24(1), 43–47.

Afolabi, J. A. 2009. An assessment of garri marketing in South West Nigeria. *Journal of Social Sciences,* 21(1): 33–38.

Akinbile, L. A. 2007. Determinants of farmers' use of sustainable soil conservation practices in Osun State, Nigeria. American-Eurasian *Journal of Agriculture and Environmental Science,* 2(5): 578–582.

Alabi O.O. and Abdulaziz I. 2018. Economics of Maize (*Zea mays*) Production in Igabi Local Government Area, Kaduna State, Nigeria. *Journal of Agriculture Faculty of Gaziosmanpasa University.* 35(3): 248-257.

Bappa, A. A. 2008. Analysis of the Structure and Performance of Egg Marketing in Damaturu Metropolitan Area, Yobe State, Nigeria. A Project Submitted to the Department of Agricultural Economics and Extension, University of Maiduguri, Nigeria.

Bello, O. W., Oyewole, S. O., and Afolabi, T. A. (2016). Marketing constraints of smallholder farmers in Nigeria: *A review. Nigerian Journal of Rural Extension and Development*, 10(1), 45–52.

FAO. (2021). FAOSTAT Statistical Database. Food and Agriculture Organization of the United Nations. Retrieved from http://www.fao.org/faostat

FAO. 2022. Nigeria at a glance. Food and Agriculture Organization of the United Nations. https://www.fao.org/nigeria

National Bureau of Statistics (NBS). 2023. Nigerian gross domestic product report Q4 2023. (https://www.nigerianstat.gov.ng)

NPC 2006. National population Commission, Nigeria 2006 Census Population Figure.Nathan, S.M, Moses, J. D. Jimjel, Z and J.M. Altine (2015) Profitability Analysis of Cowpea Production in Gombe Local Government Area of Adamawa State, Nigeria International Journal of Advances in Agricultural Science and Technology 2 (11): 1-8

Ojo, M. A., Mohammed, U. D., Ojo, A. O. and Olaleye, R. S. 2011. Return on investment in Maize production in Nigeria: Evidence from Niger state. *Journal of Agriculture and Biological Sciences*, 6(6): 30-35.

Oladejo, J. A. and Adetunji, M. O. 2012. Economic analysis of tomato marketing in Oyo State, Nigeria. *International Journal of Vegetable Science,* 18(4): 363–371.

Olayemi, J. K. 1998. Agricultural marketing in Nigeria: Problems and prospects. University of Ibadan Press.

Olorunsanya, E. O. and Omotesho, O. A. 2012. Economic analysis of food grain marketing in Kwara State, Nigeria. *International Journal of Agricultural Economics and Rural Development*, 5(1): 20–29.

Olukosi, J. O. and Eharbor, P. O. 2008. Introduction to farm management economics: Principles and applications (3rd ed.). Agitab Publishers Ltd.

Olukosi, J. O. and Isitor, S. U. 2005. Introduction to agricultural marketing and prices: Principles and applications. Living Books Series.

Olukosi, J. O., Isitor, S. U., and Ode, M. O. (2007). Introduction to agricultural marketing and prices: Principles and applications. Living Books Series.

Philip S. 2015. Multistage sampling. BMJ(online). 351.h4155.10.1136/bmj.h4155.

Yusuf, R. O. and Mohammed, U. S. 2017. Profitability analysis of orange marketers in Chanchaga Local Government Area, Niger State, Nigeria. *FUDMA Journal of Sciences*, 1(1): 45–53.

Genetic diversity and character association in pigeon pea (*Cajanus cajan* L.) based on seed morphometric and quality traits

Fajobi, R. Y.* and Oduwaye, O. A.
Department of Plant Breeding and Seed Technology,
Federal University of Agriculture, Abeokuta, Ogun State, Nigeria

ABSTRACT

Genetic diversity in plant resources gives plant breeders the opportunity to develop new and improved cultivars with desirable traits. This study examined thirteen pigeon pea (*Cajanus cajan* L.) accessions using seed morphometric and quality traits, laid out in a Completely Randomized Design (CRD) with three replicates. The experiment was conducted at the Laboratory of Plant Breeding and Seed Technology Department, Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State. Analysis of variance was conducted on the plot means for all characters to identify significant differences among the accessions. Single linkage cluster analysis (SLCA) and Principal component analysis (PCA) were used to assess genetic diversity and determine the contribution of the seed morphometric and quality characters to variation among the accessions. Correlation coefficients was used to determine the relationship between pairs of character. Significant variation ($p \leq 0.01$) was observed in Width-length ratio, seedling length, seedling vigor index and seedling dry weight. Principal Component Analysis revealed three components explaining 82% of total variation. The cluster analysis grouped the accessions into seven separate clusters (I-VII) at a similarity coefficient of around 0.40, which ranges from 0 (most dissimilar) to 1 (identical). Correlation Analysis highlighted significant positive associations between pod length and traits like Projection area (r =0.40), straight length (r =0.33), curved width (r = 0.33).

Key words: Cluster, genetic diversity, seed morphometric, similarity

***Corresponding author**: wizyet2@gmail.com

INTRODUCTION

Pigeon pea (*Cajanus cajan* (L.) Millspaugh), also known as Arhar, Tur, and Red gram, is an often cross-pollinated crop with a diploid chromosome number of 2n =2x =22 and a genome size of 833.07Mb (Varshney *et al.*, 2012). Globally, pigeon pea is ranked sixth among pulses after peas, broad beans, lentils, chicken peas and common bean (Emefiene *et al.*, 2014). It is cultivated globally on 5.4 million hectares, with an annual production of 4.49 million tons (FAO Statistics 2017). Pigeon pea seeds contain 21% protein, 53% starch, 2.3% fat, 6.6% crude fiber, and 250.3 mg of minerals per 100g (Saxena *et al.*, 2010). The seeds of this plant can be processed into a variety of meals, making them a versatile ingredient in various culinary applications.

In Nigeria, it is an indigenous crop known as "Waken Kurawa" in Hausa, "Fio-Fio" or "Agbubu" in Igbo, and "Otili" in Yoruba (Adebimpe *et al.*, 2018). Utilizing quality seeds offers several advantages, including ensuring the genetic and physical purity of the crops, achieving the desired plant population, and enhancing the capacity to withstand adverse environmental conditions. Pigeon pea output potential has stagnated over the past few years, and seed yield, in general, seems to have reached a limit. In agricultural production, the size and shape of seeds are key factors that influence seed dispersal, potential seed loss, moisture absorption, seed germination, and the quality grading of grain (Gyulai *et al.*, 2015). Understanding the distribution of genetic diversity among individuals is essential in plant breeding, as it establishes a foundation for selecting parent plants. Genetic diversity in plant resources gives plant breeders the opportunity to develop new and improved cultivars with desirable traits (Bhandari *et al.*, 2017). This study aimed to assess genetic diversity among 13 accessions of pigeon pea (*Cajanus cajan*) based on seed character and to determine relationship between seed and seed yield-related characters in the pigeon pea accessions.

MATERIALS AND METHODS

The experiment was laid out in a completely randomized design with three replicates in the laboratory of Plant Breeding and Seed Technology Department, Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, Nigeria. Thirteen accessions of pigeon pea were collected from the Germplasm Resource and Biotechnology Units of the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. Standard germination test was conducted using ten seeds from each accession were placed in petri dishes containing 20 ml of distilled water and then placed in a germination chamber for a duration of 8 days. Seed morphometric traits were collected using EPSON scanner connected a computer for image acquisition and image analysis using WinSEEDLET™ (pro version) software.

Data were collected randomly from ten seeds of each accession for seed quality; seed germination, rate of germination (%), seedling length (cm), seedling vigor index, seedling fresh weight (g) and Seedling dry weight (g) and morphometric traits; projection area, straight length (mm), curved length (mm), curved width (mm), curvature, volume circle, surface area circle, width length ratio, projection perimeter and projection form coefficient. The data collected was subjected to Single linkage cluster analysis (SLCA), Principal Component Analysis and Correlation coefficient using SAS 9.1.1.

RESULTS AND DISCUSSION

The mean square derived from analysis of variance illustrate the significant differences among thirteen accessions of Pigeon pea regarding their seed morphometric and quality traits, as shown in Table 1. Significant ($p \leq 0.01$) differences was observed between the accessions for width length ratio. Accession effect was also significant for seedling length, seedling vigour index and seedling dry weight. The result indicated the possibility to select superior accessions for these traits. Nakagawa (1999) reported the effectiveness of seedling length to discriminate between genotypes.

Table 1. Mean squares of seed morphometric and quality characters measured in 13 accessions of pigeon pea (*C. cajan*)

Character	Source of variation	
	Accession (df = 12)	Error (df = 26)
Seed morphometric		
Projection area	8.71	7.93
Straight length (mm)	3.33	1.97
Curved length (mm)	3.35	2.02
Straight width (mm)	0.07	0.11
Curved width (mm)	0.07	0.11
Curvature	0.00	0.00
Volume circle	119.43	185.81
Surface area circle	88.59	83.89
Width Length ratio	0.01**	0.00
Projection perimeter	32.70	16.61
Projection form coefficient	0.00	0.00
Seed quality		
Seedling length (cm)	30.45**	1.88
Seedling weight (g)	0.04	0.05
Germination (%)	161.97	228.21
Rate of germination	172.22	305.13
Seedling Vigor Index	30.00**	9.70
Seedling Dry Weight (g)	0.00*	0.00

* Significant at 5% probability ** Significant at 1% probability

The eigen values of the principal axes representing genetic diversity among the thirteen accessions of Pigeon pea was explained in Table 2. The first three components accounted for 82% of the total variation among the accessions, PC1 accounted for 44% of the variation and had the highest eigen value (7.55) and exhibited high loadings (≥ 0.30) for projection area, surface area circle, projection perimeter, straight length (mm), curved length (mm) and volume circle**.** PCA2 and PCA3 accounted for 23.00% and 14.00% of total variance respectively. PCA2 had the next eigen value (3.96) with high loading for straight width (0.46), curve width (0.46), and Width-Length ratio (0.41) while traits such as seedling length, germination percentage, rate of germination and seedling vigor index contributed to the loadings in PCA3. The PCA analysis revealed the potential of morphometric traits than seed quality traits to determine genetic diversity among the accessions.

Figure 1 shows the dendrogram shown depicts the hierarchical clustering of the13 pigeon pea accessions based on seed morphometric and quality traits. At 1.0 similarity coefficient none of the accessions was cluster together which indicated no duplication among the accessions. The accession formed a single cluster at 0.18 similarity coefficient which revealed that at least two accessions are diversity 82%. At 60% diversity, seven homogeneous clusters were formed among the accessions. Cluster I, IV, VI, VII, VIII were the most distinct among the cluster. Parental lines can be developed from the clusters to improve desirable traits in the Pigeon pea accessions through hybridization.

Table 2. Eigen value and vector of the first-three principal axes of seed characters measured in 13 accessions of Pigeon pea

Character	Principal axes		
	1	2	3
Projection area	0.35	0.04	0.14
Straight length (mm)	0.34	-0.08	0.14
Curved length (mm)	0.34	-0.08	0.14
Straight width (mm)	0.13	0.46	0.02
Curved width (mm)	0.12	0.46	0.02
Curvature	-0.18	0.26	0.24
Volume circle	0.31	0.21	0.08
Surface area circle	0.35	0.06	0.14
Width Length ratio	-0.17	0.41	-0.07
Projection perimeter	0.34	-0.07	0.15
Projection form coefficient	-0.28	0.27	-0.16
Seedling length (cm)	-0.17	-0.23	0.33
Seedling weight (g)	-0.07	-0.09	0.29
Germination (%)	-0.18	0.13	0.49
Rate of germination	-0.13	0.2	0.39
Seedling Vigor Index	-0.19	-0.14	0.46
Seedling Dry Weight (g)	0.14	0.25	0.08
Eigen value	7.55	3.96	2.39
Proportion	44.00	23.00	14.00
Cumulative	44.00	68.00	82.00

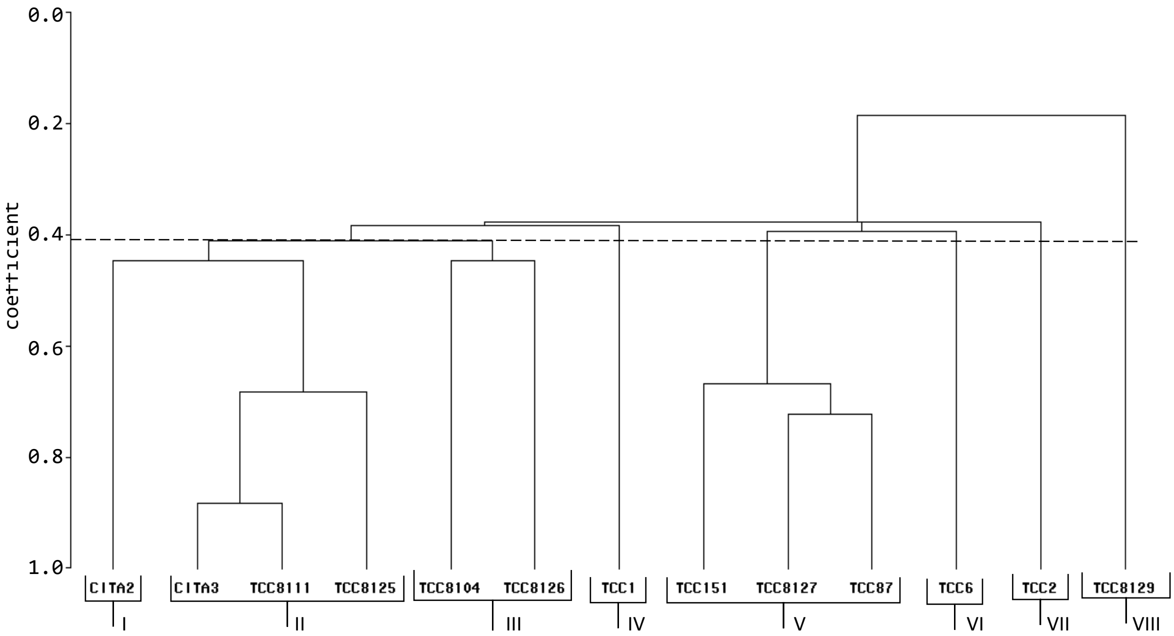


Figure 1. Genetic diversity among thirteen accessions of pigeon pea revealed by single linkage cluster analysis

The correlation coefficients between seed characteristics and yield-related traits in pigeon pea (*Cajanus cajan* L.) are illustrated in Table 3. Pod length showed a positive correlation with several traits: projection area (r = 0.56), straight length (r = 0.50), curved length (r = 0.50), volume circle (r = 0.48), projection perimeter (r = 0.46) and surface area circle (r = 0.56). Also, pod width is positively correlated with projection area (r =0.40), straight length (r = 0.33), curved width (r = 0.33), volume circle (r = 0.35), surface area circle (r = 0.33) and projection perimeter (r = 0.33). These relationships imply that larger pod measurements are closely associated with greater seed size and projected area, suggesting that accessions featuring longer pods might also yield larger or more resilient seeds.

CONCLUSION

The results revealed variability among 13 accessions of pigeon pea concerning their metric traits, particularly the width-length ratio. Similarly, significant variation was observed in seed quality parameters such as seedling length, seedling vigour index and seedling dry weight. Therefore, there is possibility to select among the pigeon pea accession for these characters. The analysis of the principal components revealed that several traits significantly contributed to the variability observed among the pigeon pea accessions studied. These traits included seed projection area, straight and curve lengths, straight and curve widths, volume and surface area of the circle, seedling vigor index, germination percentage, and seedling length. The dendrogram demonstrates a significant level of genetic diversity among the 13 pigeon pea accessions, as assessed through their seed morphometric and quality traits. The analysis of the correlation coefficients indicated that both pod length and pod width had a positive and significant correlation with several traits, including projection area, straight length, curved length, volume circle, surface area, and projection perimeter. These seeds morphometric characters can be explore for simultaneous improvement of yield through pod length and pod width.

Table 3. Correlation coefficients between seed characters and Seed yield-related characters in pigeon pea

Character	Leaf length (cm)	Leaf width (cm)	Plant height (cm)	Pod length (cm)	Pod width (cm)	Number of capsules	Number of seeds/pod	100-seed weight (g)	Seed yield (g)
Projection area	-0.2	0.00	-0.22	0.56**	0.40*	-0.14	-0.06	0.06	-0.22
Straight length (mm)	-0.31	-0.13	-0.330*	0.50**	0.33*	-0.08	0.11	0.04	-0.14
Curved length (mm)	-0.31	-0.14	-0.337*	0.50**	0.33*	-0.08	0.11	0.05	-0.15
Straight width (mm)	0.04	0.08	-0.02	0.28	0.22	-0.1	-0.21	0.13	-0.12
Curved width (mm)	0.03	0.03	-0.01	0.26	0.19	-0.12	-0.2	0.13	-0.13
Curvature	0.11	0.12	0.25	-0.47**	-0.19	-0.14	-0.27	0.29	-0.36*
Volume circle	-0.14	-0.03	-0.18	0.48**	0.35*	-0.17	-0.13	0.12	-0.25
Surface area circle	-0.22	-0.04	-0.24	0.56**	0.39*	-0.15	-0.06	0.08	-0.24
Width Length ratio	0.28	0.18	0.25	-0.3	-0.2	0.05	-0.26	0.14	0.19
Projection perimeter	-0.339*	-0.13	-0.33*	0.46**	0.33*	-0.07	0.08	0.06	-0.11
Projection form coefficient	0.342*	0.31	0.32*	-0.21	-0.13	0.11	-0.13	-0.03	0.16
Seedling length (cm)	0.36*	0.17	0.16	-0.21	-0.24	0.18	-0.05	0.06	-0.11
Seedling weight (g)	-0.03	0.17	0.14	-0.28	-0.31	0	0.11	-0.1	0.13
Germination (%)	0.21	0.40*	0.14	-0.07	-0.08	0.04	0.07	-0.04	-0.02
Rate of germination	0.09	0.24	0.24	-0.08	-0.01	0	0.12	-0.01	0.09
Seedling Vigor Index	0.33*	0.32*	0.21	-0.16	-0.1	0.11	-0.03	0.06	-0.1
Seedling Dry Weight (g)	0.02	-0.08	-0.23	0.06	-0.26	-0.02	0.04	-0.38*	-0.17

* Significant at 5% probability, ** Significant at 1% probabilit

REFERENCES

Adebimpe, O. A., Aladele, S. E. and Ojo, D. K. 2018. Characterization and sclassification of pigeonpea (*Cajanus cajan* (L.) Millsp.) landraces using seed morphology and biochemical markers. *Journal of Agricultural Research and Development*, 18(1): 1–13.

Bhandari, H. R., Bhanu, A. N., Srivastava, K., Singh, M. N., Shreya, J. and Hemantaranjan, A. 2017. Assessment of genetic diversity in crop plants - an overview. *Adv. Plants Agric. Res.,* **7**(3): 00255.

Emefiene, M. E., Joshua, V. I., Nwadike, C., Yaroson, A. Y. and Zwalnan, N. D. E. 2014. Profitability analysis of pigeon pea (*Cajanus cajan*) production in Riyom LGA of Plateau State. *International Letters of Natural Sciences*, 18: 73–88.

FAO Statistics. 2017. *FAOSTAT statistical database*. http://faostat.fao.org.

Gyulai, G., Rovner, I., Vinogradov, S., Kerti, B., Emödi, A., Csákvárf, E., Kerekes, A., Mravcsik, Z. and Gyulai, F. 2015. Digital seed morphometry of dioecious wild and crop plants: Development and usefulness of the seed diversity index. *Seed Science and Technology*. 43(3): 492–506.

Nakagawa, J. 1999. Testes de vigor baseados no desempenho das plântulas. In F. C. Krzyzanowski, R. D. Vieira and J. B. França Neto (Eds.), *Vigor de sementes: conceitos e testes*. . (pp: 2.1–2.24). ABRATES.

Saxena, K. B., Kumar, R. V. and Gowda, C. L. L. 2010. Vegetable pigeonpea—A review. *Journal of Food Legumes,* 23(2): 91–98.

Varshney, R. K., Glaszmann, J. C., Leung, H. and Ribaut, J. M. 2012. Agricultural biotechnology for crop improvement in a variable climate: Hope or hype? *Trends in Plant Science*, 17(7): 363–371.

Incidence and population dynamics of leafhoppers (*Amrasca biguttula biguttula* (L.) Moench) on Okra (*Abelmoschus esculentus* (L.) Moench accessions

Alabi, O. Y.* and Olamuyiwa, V. T.
Department of Crop Protection and Environmental Biology, University of Ibadan, Nigeria.

ABSTRACT

Okra is a vegetable crop known for its beneficial anti-inflammatory and antioxidant properties. However, it faces a significant threat from *Amrasca biguttula biguttula*, which feeds on sap and causes phytotoxic damage called hopper burn, leading to reduced yields. To create effective management practices, it is essential to understand how weather conditions affect leafhopper populations on okra and to identify resistant plant accessions. Three okra accessions, NGB00346, NGB00469, and NGB00303, were sown in pots (n=30). Parameters assessed from 10 randomly selected plants between 20 and 70 days after planting (DAP) were plant height, number of eggs, nymphs, and adults, and hopper burn severity rated on a scale: (1: normal leaves, to 9: over 80% discolouration and stunting. Additionally, pod yield (g/plant) was recorded. Temperature, relative humidity, and rainfall data were accessed from a weather station at the University of Ibadan. Plant heights varied from 13.77 cm (NGB00303) to 40.52 cm (NBG00469). At 28 DAP, leafhopper eggs were found in greater numbers on NGB00469 (11.6) and fewer on NGB00303 (4.6). At 28 DAP, the adult leafhopper population was higher on NGB00303 (0.64) and lower on NGB00346 (0.26). The severity of hopper burn showed significant variation, ranging from 1.00 in NGB00346 at 42 DAP to 6.80 in NGB00303 at 63 DAP. Maximum temperature had a negative correlation of -0.7830 with the adult population on NGB00303. Accessions NGB00346 and NGB00303 possess attributes that minimise leafhopper colonisation and damage. Temperature is a key factor in regulating leafhoppers.

Key words: *Amrasca biguttula biguttula,* hopper burn, okra accessions, NGB00303, tolerance

***Corresponding author**: alabi.jummy@gmail.com

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench), commonly known as "lady's finger," belongs to the Malvaceae family (Ndunguru and Rajabu, 2004; Naveed *et al*., 2009). Its immature green fruit is succulent and highly nutritious. In Nigeria, okra is widely grown in home gardens and is valued for its fruits, seeds, flowers, stems, and leaves consumed immature in a gelatinous soup that pairs well with coarse starchy foods. This vegetable is also significant in other tropical regions, including Central Asia and South America. In Africa, okra is cultivated during both wet and dry seasons, with higher profits realised during the dry season due to increased demand (Uwiringiyimana *et al*., 2024). Okra is a valuable source of vitamins A, B, C, and K, as well as minerals like iron and iodine. It is rich in viscous fibre and has anti-inflammatory, anti-hyperglycemic, anti-hyperlipidemic, and antioxidant properties (Uwiringiyimana *et al*., 2024; Gemede *et al*., 2015). The oil from okra seeds includes oleic and linoleic acids (Jarret *et al*., 2011) and provides essential carbohydrates, potassium, vitamins, and minerals often lacking in the diets of people in developing countries. Okra seeds can be dried and milled into flour, which is high in protein and oil (Uwiringiyimana *et al*., 2024). While scientifically a fruit, okra is typically used as a vegetable in cooking. It exists in green and red varieties, which taste the same, with the red turning green when cooked. Both types thrive in tropical and subtropical regions.

Okra is an important crop, but leafhoppers (*Amrasca biguttula biguttula*) pose a significant challenge to its production. These pests feed on plant sap, causing symptoms like yellowing leaves, leaf curling, and reduced growth, which can lead to yield losses of 50% to 63.4% (Ilse, 2000; Ounis *et al*., 2024). Both nymphs and adults contribute to the damage, complicating control efforts (Singh *et al*., 2018). Their ability to thrive in various conditions and reproduce quickly worsens the problem. Additionally, improper pesticide use can lead to resistance and harm beneficial organisms (Dodda and Balikai, 2014). These issues emphasise the need for sustainable pest management strategies, including resistant okra varieties and integrated pest management (IPM) approaches. To manage infestations of *A. biguttula biguttula* in okra cultivation, several control measures have been adopted. Chemical control, which involves the use of pesticides, remains the most common approach (Acharya *et al.,* 2012; Dodda and Balikai, 2014). However, overuse and improper application have led to issues such as pesticide resistance, environmental pollution, and health risks to humans. As an alternative, cultural practices such as crop rotation, intercropping, and maintaining proper plant spacing have been recommended to reduce pest incidence. Additionally, biological control methods, such as biopesticides, play a role in minimising leafhopper populations (Lal and Dhurve, 2024; Mollah, 2024). However, the effectiveness of biological control is often influenced by environmental factors (Mollah, 2024).

Despite the application of these management strategies, infestations of *A. biguttula biguttula* continue to rise. This persistent threat has prompted researchers to explore the development of okra varieties resistant to the pest, as well as to investigate the impact of environmental factors on pest population dynamics. Host plant resistance (HPR) is an eco-friendly pest control method that uses crop varieties with natural resistance to reduce chemical pesticide use, lower production costs, and minimize environmental impact (Chand, 2021). Resistance mechanisms include antibiosis (affecting pest survival), antixenosis (reducing pest preference), and tolerance (allowing plants to withstand damage). Despite its benefits for sustainability, concerns about pest adaptation and limited genetic diversity necessitate integrating HPR with other pest management strategies for long-term effectiveness (Zhou *et al*., 2024). Key factors affecting insect pest growth and reproduction significantly impact crop production. Choosing the right crop varieties influences pest populations, while temperature, humidity, and rainfall are also crucial. Understanding leafhopper dynamics helps agricultural stakeholders manage these pests effectively protecting the crop and ensuring a successful harvest (Meena *et al*., 2020). The objectives of this study are to assess the population and damage of leafhoppers on three accessions of okra and determine the role of weather parameters on the hopper populations.

MATERIALS AND METHODS

Study Area

The experiment was conducted at the Crop Garden of the Department of Crop Protection and Environmental Biology, University of Ibadan, Nigeria. 7°27'02.5"N 3°53'50.1"E.

Source of Okra Accessions

The three okra accessions used for the study were: NGB00346, NGB00469, NGB00303. These accessions were obtained from the National Center for Genetic Resources and Biotechnology (NACGRAB), Ibadan, Nigeria. The institute is a premier organisation responsible for genetic conservation, breeding, and distribution of crop germplasm in the country.

3.3 Experimental Design

The experiment was conducted using a randomised complete block design with three replications. The experiment included three plots, one for each okra accession. Crops were planted in poly pots arranged in rows, with a spacing of 30 cm between plants within a row and 50 cm between rows to promote adequate growth and airflow. Standard agronomic practices, including uniform watering and weeding were consistently applied across all plots. To observe the natural dynamics of leafhopper infestation, no chemical or biological pest control measures were implemented, allowing the experiment to proceed under natural insect pressure.

Data Collection

Population Dynamics of Amrasca biguttula biguttula

For pest monitoring, 30 plants (10 per replication) were randomly selected and tagged. The population of *A. biguttula biguttula* was observed weekly for 8 weeks from October 2024 to January 2025. During each inspection, data on the number of eggs, nymphs, and adults were recorded from the top, middle, and bottom leaves, as well as the stem. Other observations include plant height and hopper burn. Data on plant height was collected bi-weekly starting from the third week after planting, the plants were scored weekly for hopper burn symptoms starting from the sixth week after planting.

Fruiting and Harvesting

Matured fruits were harvested from the replications contained in each okra accession and weighed with a weighing balance. The observed weights per plant for the replications contained in each accession were recorded. The variables were correlated with leafhopper population dynamics to assess their influence on the quantity of fruit produced per plant in an accession.

Weather Data

Meteorological data, including daily rainfall, temperature, and sunshine hours, were obtained from the Department of Soil Resources Management. The variables were correlated with leafhopper population dynamics to assess their influence on pest activity.

Data Analysis

The collected data were analyzed with Analysis of Variance using DSAASTAT ver. 1.101 to determine significant differences in leafhopper populations across the three okra accessions. Means were compared with LSD value at $p \leq 0.05$ and the correlation analysis between weather parameters and leafhopper adult populations was determined.

RESULTS

Heights of three okra (*Abelmoschus esculentus*) accessions measured during leafhopper (*Amrasca biguttula biguttula*) incidence

The heights of the three accessions of okra measured between 20 and 62 days after planting is presented in Table 1. At 20, 34, 48, and 62 days after planting the height of NGB00303 was significantly lower (13.77, 18.93, 26.73, and 30.78) than NGB00346 and NGB00469. The height of NGB00346 was highest among the accessions and it ranged from 15.17 cm to 41.25 cm but it was similar to NGB00469 (14.85 – 40.52 cm).

Population of leafhopper (Amrasca biguttula biguttula) eggs on three okra accessions.

Figure 1 shows the mean number of eggs laid by leafhoppers on the three okra accessions between 21 to 70 days after planting. More eggs were laid on NBG00469 while fewer eggs was laid on NGB00303 compared to the other accessions. The number of eggs laid on the three accessions peaked at 42 days after planting.

Table 1: Plant heights (cm) of the okra accessions from 20 to 62 days after planting

Accession	20DAP	34DAP	48DAP	62DAP
NGB00303	13.77[b]	18.93[b]	26.73[b]	30.78[b]
NGB00346	15.17[a]	21.27[a]	33.14[a]	41.25[a]
NGB00469	14.85[a]	21.73[a]	32.38[a]	40.52a
LSD	0.59	1.32	2.53	4.11

Means in the same column followed by the same letter(s) are not significantly different at $p > 0.05$, DAP: Days after planting

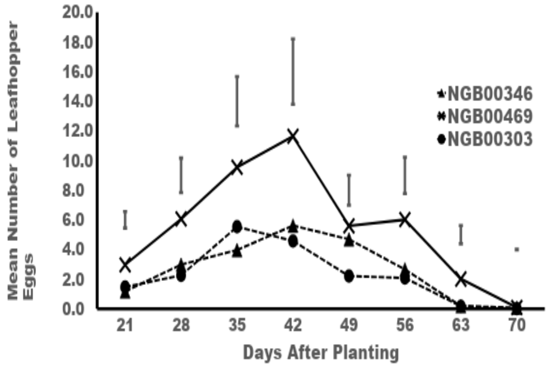


Figure 1: Mean number of leafhopper eggs on three accessions of okra

Population of leafhopper adults on three okra accessions

Figure 2 shows the mean number of leafhopper adults on the three okra accessions from 21 to 70 days after planting. NGB00346 had the lowest adult population compared to the other accessions. The number of adults on the three accessions peaked at 28 days after planting.

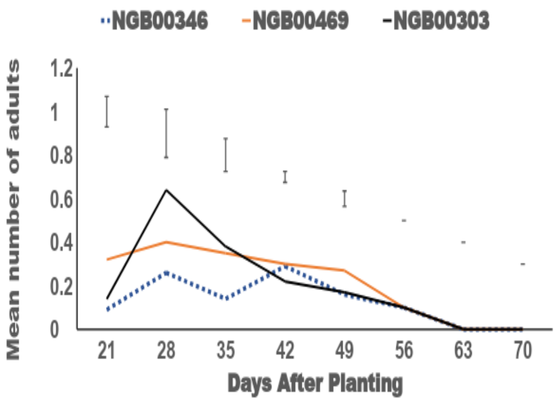


Figure 2: Mean number of leafhopper adults on three accessions of okra

Hopper Burn Severity on three okra accessions

Table 2 shows the severity of hopper burn on okra accessions observed from 42 to 63 days after planting. Among the accessions, hopper burn severity was lower on NBG00346 than on the others. NGB00303 had the highest hopper burn damage 63 days after planting (6.80), but it was not significantly different from NGB00469 (6.70).

Table 2: Severity of hopper burn on okra accessions observed from 42 to 63 days after planting

Accession	42DAP	49DAP	56DAP	63DAP
NGB00303	2.67[a]	3.67[a]	4.23[a]	6.80[a]
NGB00346	1.00[b]	2.00[b]	3.60[a]	5.67[b]
NGB00469	3.27[a]	2.33[b]	3.87[a]	6.70[a]
LSD	0.68	0.64	0.79	0.79

Means in the same column followed by the same letter(s) are not significantly different at $p > 0.05$, DAP: Days after planting

Weight of okra pods per plant for different accessions.

Table 3 shows the weight of okra pods per plant for different accessions. There was no significant difference in the weight of okra pods per plant for NGB00303, NGB00346, NGB00469 which was 2.49, 3.00, 3.15 respectively.

Table 3: Weights of okra pod on the three accessions

Accession	Okra pod weight/plant
NGB00303	2.49[a]
NGB00346	3.00[a]
NGB00469	3.15[a]
LSD	2.36

Correlation of the population of leafhoppers (Amrasca biguttula biguttula) on the three accessions of okra with weather parameters from October to December 2024

Table 4 shows the correlation of the population of leafhoppers on the three accessions of okra with weather parameters (maximum temperature, minimum temperature, rainfall (mm/day), relative humidity (%) from October to December 2024. The population of leafhoppers on NGB00303 had a significant negative correlation of -0.7830 with maximum temperature. This therefore depicts that as temperature increases, the leafhopper population decreases on the accession.

Table 4: Correlation of population of leafhoppers with weather parameters from October to December 2024

Weather parameters	Accessions		
	NGB00346	NGB00469	NGB00303
Max Temp °C	- 0.39	- 0.67	- 0.78
MinTemp°C	- 0.19	- 0.19	- 0.51
Rainfall (mm/day)	- 0.02	0.41	0.11
Relative Humidity (%)	0.09	0.53	0.38

DISCUSSION

The population dynamics and incidence of okra leafhoppers were studied across three okra accessions. Variability was observed in the plant characteristics, as well as in leafhopper infestation and damage. NGB00303 accession was shorter than other accessions, hence leafhoppers were deterred from colonizing the crop. According to Halder *et al.* (2015), tall okra plants are more susceptible to jassid and whitefly attacks. This also explains the low incidence of leafhopper eggs on the accession. The higher number of eggs laid on NGB00469 indicates that this accession is preferred for oviposition, likely due to the lack of obstructive structures on the leaf's abaxial (lower) surface.

It is noteworthy that very few eggs were laid on NGB00303. Biophysical factors, such as hairiness and trichomes, may have impaired oviposition. Tanni *et al.* (2019) stated that leaf trichomes may be responsible for lower pest incidence. Population of eggs laid on okra leaves was highest at 42 days after planting across all the accessions. Control measures should be implemented between 21 and 28 days after planting to prevent increased adult populations. The number of adults peaked on all accessions at 28 Days after Planting (DAP).

To reduce damage to okra, targeting 21 to 28 days after planting for pest control is crucial to minimise population build-up on the crop. The hopper burn severity scores were significantly lower on NGB00346 at 42, 49, and 63 DAP. This was due to the accession supporting a low population of eggs and adults. Another reason the jassids colonised plants less frequently is that the accessions may possess biochemical properties that could be responsible for low pest attacks.

Pod yield was similar among the accessions, despite variations in their response to leafhopper infestation and damage. This suggests that the plants have unique characteristics that provide resistance against leafhopper damage. The correlation analysis revealed that only maximum temperature and adults on NGB00303 had a significant negative correlation (r) of -0.7830. Temperature greatly influences basic physiological processes and interactions between plants and pests (Salim and Saxena, 1991). There is a high probability that temperature-stressed plants release fewer allelochemicals that influence insect-plant interactions.

During rice production, Chen *et al.* (2013) reported that chalkiness is highly influenced by high temperature during the ripening phase, and it varies among varieties. Hayamanesh *et al.* (2023) stated that high temperature can impair okra development and productivity. A few minutes' exposure to a temperature above optimal can result in heat shock and disrupt physiological processes. Heat shock reduces photosynthesis, chlorophyll fluorescence and stomatal conductance (Zhu *et al.*, 2021). This could be the reason why NGB00303 had fewer leafhoppers than other accessions.

CONCLUSION

The study-highlighted variability in plant heights, egg populations, adult leafhopper counts, and hopper burn severity among the three okra accessions assessed. The low numbers of eggs and adults, along with reduced hopper burn severity observed on NGB00346, indicate that this accession exhibits resistance to leafhopper infestation, making it a preferable option for farmers. Incorporating resistant varieties like this into an integrated pest management strategy could effectively help manage leafhoppers in okra cultivation.

Despite higher leafhopper activity observed on NGB00303 and NGB00469, these accessions produced comparable pod yields, suggesting they are tolerant varieties. Furthermore, maximum temperature influenced leafhopper populations across the accessions. With careful monitoring and management, cultivating okra in conditions where the maximum temperature remains conducive to plant health yet unfavorable to leafhoppers could serve as an effective physical strategy to control their incidence and population dynamics.

REFERENCES

Acharya, S., Mishra, H. P. and Dash, D. 2002. Efficacy of Insecticides against Okra Jassid, *Amrasca biguttula biguttula* Ishida. *Annals of Plant Protection Sciences*, 10 (2). 230-232.

Chand, H. 2021. Host Plant Resistance in Pest Management. *Tropical Agrobiodiversity*, 2(2): 54-58.

Chen, C. H., Jianliang, Z., Liyang, S., Farooq, N., Lixiao, C., Kehui, P. and Shaobing. 2013. Varietal difference in the response of rice chalkiness to temperature during ripening phase across different sowing dates. *Field Crops Research*, 151: 85 - 91. 10.1016/j.fcr.2013.07.016.

Dodda, C. S. and Balikai, R. 2014. Insecticide Resistance In Cotton Leafhopper, *Amrasca Biguttula Biguttula* (Ishida) – A REVIEW. Biochemical and Cellular Archives.

Gemede, H. F., Haki, G. D., Beyene, F., Woldegiorgis, A. Z. and Rakshit S., K. 2015. Proximate, mineral, and antinutrient compositions of indigenous Okra (*Abelmoschus esculentus)* pod accessions: implications for mineral bioavailability. *Food Sci Nutr. Sep* 17; 4(2): 223-33. doi: 10.1002/fsn3.282. PMID: 27004112; PMCID: PMC4779480.

Halder, J., Sanwal, S. K., Deb, D. Rai, A. B. and B Singh, B. 2015. Mechanisms of physical and biochemical basis of resistance against leaf-hopper (*Amrasca biguttula biguttula)* in different okra (*Abelmoschus esculentus*) genotypes. *Indian Journal of Agricultural Sciences,* 86 (4): 481–4.

Hayamanesh, S., Trethowan, R., Mahmood, T., Ahmad, N. and Keitel, C. 2023. Physiological and Molecular Screening of High Temperature Tolerance in Okra *Abelmoschus esculentus* (L.) Moench. *Horticulturae,* 9: 722. https://doi.org/10.3390/horticulturae 9060722

Jarret, R., Wang, M. and Levy, I. 2011. Seed Oil and Fatty Acid Content in Okra (*Abelmoschus esculentus*) and Related Species. *Journal of agricultural and food chemistry*, 59: 4019-24. 10.1021/jf104590u.

Lal, B., and Dhurve, V. 2024. Bio-efficacy of Different Biopesticides against Jassid, (*Amrasca biguttula biguttula Ishida*) Infesting Okra [*Abelmoschus esculentus* (L.) Moench]. *Journal of Experimental Agriculture International*, 46: 37-47. 10.9734/jeai/2024/v46i12289.

Meena, R. K., Meena, R. K., Singh, U. and Meena, M. L. 2020. Bio-efficacy of different insecticides against leaf hopper, *Empoasca kerri* Pruthi (Cicadellidae: Hemiptera) in clusterbean. *International Journal of Plant Protection,* 13(1): 24-29, DOI: 10.15740/HAS/IJPP/13.1/24-29.

Mollah, M., and Mahi, I. 2024. Efficacy evaluation of some bio-insecticides against green leaf hopper (*Amrasca biguttula biguttula* Ishida) infesting brinjal. *Journal of Entomological and Acarological Research*, 56: 10.4081/jear.2024.12398.

Naveed, A., Khan, A. A., Khan, I. A. 2009. Generation mean analysis of water stress tolerance in okra (*Abelmoschus esculentus* L.). *Pak. J. Bot.*, 41: 195-205.

Ndunguru, J. and Rajabu, A. C. 2004. Effect of okra mosaic virus disease on the above-ground morphological yield components of okra in Tanzania. *Scienta Horticulturae*, 99: 225-235.

Ounis, S., Turóczi, G. and Kiss, J. 2024. Arthropod Pests, Nematodes, and Microbial Pathogens of Okra (*Abelmoschus esculentus*) and Their Management—A Review. Agronomy, 14(12), 2841. https://doi.org/10.3390/agronomy14122841.

Salim, M. and Saxena R. C. 1991. Temperature Stress and Varietal Resistance in Rice: Effects on Whitebacked Planthopper Crop Ecology, Production & Management p. 1620-1625

Singh, A., Singh, J., Singh, K. and Rani, P. 2018. Host Range And Biology Of *Amrasca Biguttula Biguttula* (Hemiptera: Cicadellidae).

Tanni, A. S., Maleque M. A., Choudhury M. A. R., Khan A. U. and Khan. U. H. S. 2019. Screening of exotic okra genotypes to explore breeding materials for developing pest resistant and high yielding okra variety. Department of Entomology, Sylhet Agricultural University, Sylhet 3100, Bangladesh pg 17-26

Uwiringiyimana, T., Habimana, S., Umuhozariho, M. G., Bigirimana, V. P., Uwamahoro, F., Ndereyimana, A. and Naramabuye, F. X. 2014. Review on Okra (*Abelmoschus esculentus* (L.) Moench) Production, Nutrition and Health Benefits. *Rwanda Journal of Agricultural Sciences*, 3(1): 71-87.

Zhou, W., Arcot, Y., Medina, R. F., Bernal, J., Cisneros-Zevallos, L. and Akbulut, M. E. S. Integrated Pest Management: An Update on the Sustainability Approach to Crop Protection. ACS Omega. Sep 28; 9(40): 41130-41147. doi: 10.1021/acsomega.4c06628. PMID: 39398119; PMCID: PMC11465254.

Zhu, L., Li, H., Thorpe, M.R., Hocart C. H. and Song, X. 2021. Stomatal and mesophyll conductance are dominant limitations to photosynthesis in response to heat stress during severe drought in a temperate and a tropical tree species. *Trees* 35, 1613–1626. https://doi.org/10.1007/s00468-021-02140-9.

Yield and yield components response of tigernut (*Cyperus esculentus* l.) varieties to different sources of organic manure

[1]Adeshola, T. A.*, [1]Fabunmi, T. O., [2]Adigbo, S. O., [3]Adejuyigbe, C. O. and [2]Fadeyi, O. J.

[1] Department of Plant Physiology and Crop Production, [2] Institute of Food Security, Environmental Resources and Agricultural Research (IFSERAR) [3] Department of Soil Science and Land Management, Federal Univesity of Agriculture, Abeokuta, Ogun State, Nigeria

ABSTRACT

Sustainable soil fertility management is essential for improving the productivity of underutilized crops such as tigernut (*Cyperus esculentus* L.), which has growing economic and nutritional importance. This study investigated the growth and yield response of two tigernut varieties to different organic manure sources under field conditions. The experiment was conducted using a 2 × 3 factorial fitted into a randomized complete block design with three replications. Treatments consisted of two tigernut varieties (Yellow and Brown) and four manure sources: poultry manure, cattle dung, sheep dung, and a control (no manure). Yield parameters including tuber yield and yield components such as fresh weight, Dry Weight, number of tuber, tuber diameter and 100 tuber weight were collected. Results revealed significant ($p \leq 0.05$) effects of manure source and tigernut variety on all measured parameters. Poultry manure consistently outperformed other sources, producing the highest tuber yield, particularly in the Yellow variety. The interaction of tigernut variety and manure sources resulted in the highest fresh tuber yield (8.6 t/ha) recorded for the yellow variety at the application of poultry manure. The study concludes that poultry manure is a superior organic amendment for optimizing tigernut production, and its integration into tigernut farming systems with the cultivation of the yellow variety could sustainably enhance yield and soil health.

Key words: *Cyperus esculentus*, fertilizer, organic yield response, poultry manure, Tigernut

***Corresponding author:** titilolaadeshola@gmail.com

INTRODUCTION

Tigernut (*Cyperus esculentus* L.), a member of the Cyperaceae family, is an underutilized crop known for its edible tubers rich in dietary fiber, oil, and essential minerals. It is a cosmopolitan annual crop which belongs to the same genus as the papyrus plant which is very common in seasonally flooded wetlands (Belewu and Belewu, 2007; Bamishaiye, 2011). Tigernut is also known as yellow nut sedge, zulu nut, earthalmond, "chufa" in Spanish,"souchet"in French, "ermandeln"in Germa,"cicoda" or "cicada" in Hindi, "isipaccara" in Effik,"ishoho" in Tiffi, "ofio omu", "imumu", "ekuro tapa", "erunsha" in Yoruba, "haya" and "rigiza" in Hausa and "Aki" among the Igbos in Nigeria (Okafor *et al.*, 2003). Tigernuts are edible, nutty, sweet and flavoured tubers containing protein, carbohydrate, sugars, oil, fiber, less anti-nutritional factors especially polyphenol (Okafor *et al.*, 2003).It has been a major food crop cultivated in northern Nigeria and other African countries, India, the Middle East and Spain. It is a tuber that grows freely and is consumed widely in Nigeria, other parts of west Africa, east Africa, parts of Europe particularly Spain as well as in the Arabian Peninsula (Abaejoh *et al.*, 2006). Tigernuts are tubers, like sweet potato, though much smaller in size. They got their name from the stripes on the tubers' exterior and believed to be important energy source for prehistoric people (Bamishaiye and Bamishaiye 2011). In recent years, it has gained popularity due to its nutritional and health benefits, particularly among individuals with lactose intolerance and those seeking gluten-free alternatives. Despite its potential, tigernut production in sub-Saharan Africa remains low, partly due to poor soil fertility and inadequate crop management practices.

There are three major varieties of tigernut cultivated in the country namely: black, brown and yellow. Only two varieties (yellow and brown) are readily available in the markets (Aremu *et al*., 2016). The yellow variety is more preferred to all other varieties because of its intrinsic properties such as its bigger size, fleshier body and attractive colour (Aremu *et al*., 2016). Similarly, the yellow variety yields more milk upon extraction, contains lower fat and more proteins, and possesses less anti-nutritional factors especially polyphenols (Aremu *et al*., 2016; Musa and Hamza, 2013). Emuroti, (2017), reported that the yellow and the brown varieties are highly nutritious and that the brown variety can be substituted for the yellow variety. Unfortunately, despite the potential benefits in tigernuts, it has been an under-utilized and neglected crop in Nigeria which may be due to inadequate knowledge on its production, utilization and nutritional value (Ndubuisi, 2009).

Organic manures, such as poultry manure, cow dung, and sheep dung, offer a sustainable means of improving soil fertility, enhancing plant nutrition, and increasing yield, especially in low-input farming systems. The effectiveness of these organic inputs varies with their nutrient content, decomposition rate, and interaction with crop varieties. Previous studies have documented the benefits of organic manures on root and tuber crops, yet limited information exists on their impact on tigernut varieties. Information regarding tigernut fertilization is little in published literature (Irvine, 1969) and fertilization requirements of tigernut were variable (Pascual and Maroto 1982, Yarrow and Yarrow, 2005 and Harper, 2008). Tigernut crop that was fertilized at 100 kg/fed nitrogen fertilizer with 15m3 /fed R.S.C. plus bio-fertilizer nitrogen at 4 kg/fed appeared to be most appropriate and suitable for harvesting a good crop of tigernut tubers, fixed oil quality and maximum value of unsaturated fatty acid under the conditions of the experiment (Reference) . (Reference) reported that the nitrogen fertilizer should not be applied alone, rather in combination with compost or bio-fertilizer. Therefore, for good soil fertility and tigernut yield, it is important that the addition of a fast releasing nutrient source to biochar be sought (Adekiya *et al*., 2020). We can therefore conclude that, the above fertilizer mixture and rate is the best combination that will enhance the growth and yield of tigernut. Tigernut relatively lesser known and underutilized crop, many of which are potentially valuable as human and animal food, has been identified to maintain a balance between population growth and agricultural productivity particularly in the tropical and sub-tropical areas of the world (Adejuyitan, 2011). Tigernut productivity was enhanced on sandy clay soil when poultry manure was applied, while pig manure had a positive effect on tigernut production on loamy fine sand and sandy clay soil (Smýkal *et al*., 2015). This study aims to evaluate the growth and yield response of two tigernut varieties to different organic manure sources, with a view to identifying optimal combinations for sustainable production.

MATERIALS AND METHODS

Study area: Location of the experiment

The experiment was conducted at The Nation al Centre for Genetic Resources and Biotecno logy (NACGRAB) in South West Local Gover nment Area of Oyo State, South Western Nigeria. The site lies within the rain-forest agro ecological zone of Nigeria. (Longitude

7°33[1]N and Latitude 3°56[1]E altitude) and 168 m above sea level. The research field of the National Centre for GeneticResources and Biotechnolog (NACGRAB) has been uder continuous cultivaion for more than 15 years.

Experimental treatments and design

The experiment was a 2 × 3 factorial experiment fitted into a Randomized Complete Block Design (RCBD) and the treatments consisted of three factors. Factor A; Two varieties (Yellow variety and Brown variety). Factor B; Three types of manures (Poultry [Layers droppings], Cattle dung and Sheep dung) replicated three times given a total experimental number of 72 plots. Gross plot size was 2m × 3m (6 m^2) and 0.5m between plots and 1m between blocks. The experiment consisted of two trials: late planting season in the first year (2019) and early planting season in the second year (2020).

Sources of planting material:

The two varieties of tigernut seeds were sourced from the local market.

Sources of animal manure:

Cured Poultry manure, cow dung and sheep dung were sourced from the Institute of Agricultural Research and training (IAR&T) Moor Plantation Ibadan.

Manure application:

Cured poultry manure (layers droppings), cow dung, and sheep dung were applied and incorporated with hoe 1 week before transplanting.

Nursery stage of the planting material:

Tigernut seedlings were primed by soaking the tubers in water for 24 hours and then preger minated with moistened sawdust for 1 week (Fabunmi *et al*., 2016) before transplanting to the experimental field.

Date of transplanting:

The healthy seedlings were transplanted a week after emergence at the rate of 1 seedling per hole and at the spacing of 0.5m × 0.25m in August 2019 and April 2020.

Seedlings transplanting: Transplanting of the tigernuts seedlings were done one week at the spacing of 0.50 m × 0.25 m having the plant population of 3,456 plant stands for each trial.

Cultural practices

The site was cleared of existing vegetation and properly tilled, using mechanical implements. Ploughing was done followed by harrowing, and the removal of stumps and weeds debris. It was thereafter marked into plots. Land used was 700 m^2 (28 m × 25 m). The land was marked out into 3 replicates with 24 plots per block, making a total of 72 plots. Planting was done manually at a depth of about 5 cm for each seedling.

The layout was carried out using pegs, measuring tape and ropes using the 3-4-5 layout method. Each gross experimental plot was 2 m × 3 m (6 m^2), marked out with walk-way of 0.5 m between plots and 1 m between replicates. A rectangular raised bed with the height of 40 cm were made to achieve a uniform distribution and incorporation of the manure applied. The seedlings were planted on May 5th at NACGRAB, 2019 and 2020 respectively. Tigernut seedlings were transplanted at a spacing of 0.5m × 0.25m to give a population of 3,456 plant stands/ha. Replacement of missing stands (supplying) so as to achieve optimum plant population was done at one week after seedlings establishment (WASE).

Wire mesh of the height of 1 meter from ground level was used to net the experimental field to prevent rodent intrusion. Weed control was done manually by hoe weeding and was carried out at 3, 6 and 9 weeks after planting (WAT) to prevent negative effects of weeds on the cultivated crop.

Data collection

The following yield parameters were collected on tigernut plant:

*Tuber yield and yield component***:** this was done within the net plot (2 m × 1 m) and was expressed in kilogram per hectare, fresh weight was determined by weighing the tubers on a top load scale and recorded to compute tuber yield in tonnes per hectare; *Fresh and dry weight of tubers/plot (g):* fresh and dry weights was determined by weighing the tubers on a top load scale and recorded to compute tuber yield in tonnes per hectare; *Number of Tubers*: this was done by visual counting of tubers and was recorded; *Tuber girth (cm):* this was done by the use of a digital Vernier calliper to measure the girth of the tubers. Average tuber girth per plant was calculated and recorded to compute tuber girth per plot; *1000-Tuber weight/Plot (g):* This was done by counting the tubers and weighed with the use of METTLER PM4000 scale; *Categorization of Tubers*: This was done with the use of grading tray with the hole graduation of 12.07 mm (Fabunmi *et al*., 2018) for the grading of tubers into small, medium and large.

RESULTS AND DISCUSSION

Effects of Variety and Manure Source on Yield and Yield Parameters of Tigernut

The results presented in 7 evaluate the effects of two tigernut varieties and three manure sources (cattle, poultry, and sheep) on these yield parameters across the 2019 and 2020 cropping seasons. The Brown variety significantly ($p \leq 0.05$) outperformed the Yellow variety in terms of fresh weight (10.3 vs. 9.1 t/ha), dry weight (3.0 vs. 2.7 t/ha), and number of tubers per plant (534.8 vs. 304.8). Conversely, the Yellow variety had larger tuber diameter (12.3 mm vs. 7.4 mm) and significantly ($p \leq 0.05$) higher 100-tuber weight (142.2 g vs. 64.7 g). These results highlight genotypic variability in yield partitioning. The Brown variety appears to prioritize tuber multiplicity (more but smaller tubers), while the Yellow variety favors tuber size and weight. Similar varietal differences in tuber yield traits have been observed by Adekiya *et al.* (2020), who reported that yield response in tigernut varies significantly ($p \leq 0.05$) depending on genetic makeup, with some varieties producing fewer but larger tubers. The Brown variety maintained its superiority in number of tubers (487 vs. 427) and 100-tuber weight (124.8 g vs. 61.4 g), despite a general reduction in overall yields compared to 2019. The Yellow variety maintained higher tuber diameter (11.08 mm vs. 6.71 mm), consistent with its trend in 2019. Statistical analysis revealed that varietal differences were significant ($p \leq 0.05$) for fresh weight ($p \leq 0.05$) in 2020 but non-significant ($p \leq 0.05$) for number of tubers, suggesting environmental influence on varietal expression. The drop in productivity in 2020 can be linked to lower rainfall (685.3 mm) compared to 2019 (956.1 mm), which could have limited nutrient mineralization and water availability—key drivers of tuber formation (Ibrahim *et al.*, 2023). Although no statistically significant ($p \leq 0.05$) differences were found among manure sources for fresh/dry weight, tuber number, or 100-tuber weight, some trends are notable: Sheep manure yielded the highest number of tubers (425.1) and highest 100-tuber weight (123.1 g). Cattle manure slightly outperformed others in tuber diameter (9.8 mm vs. 9.9–10.0 mm). Again, no significant ($p \leq 0.05$) differences were observed for most parameters, except for tuber diameter, which showed a significant ($p \leq 0.05$) difference. Cattle manure resulted in the largest tuber diameter (8.97 mm). Sheep manure produced the highest number of tubers (583) and highest 100-tuber weight (105.8 g), indicating its potential as a superior nutrient source for tuber development. Sheep manure is rich in organic matter and nutrients, particularly potassium and nitrogen, which are essential for carbohydrate translocation and tuber bulking (Nwite *et al.*, 2021; Aderibigbe *et al.*, 2022). Poultry manure, known for its rapid mineralization, may have released nutrients early, supporting vegetative growth but less effectively sustaining tuber development during the bulking stage.

Variety × Manure Source Interaction on yield and yield components

In 2019, a significant ($p \leq 0.05$) interaction was observed for number of tubers and tuber diameter, suggesting that the response of tigernut varieties to different manure sources varied. In 2020, all interaction effects were non-significant ($p > 0.05$), reflecting the dominant influence of environmental stress on treatment responses. The significant ($p \leq 0.05$) interaction in 2019 implies that optimal manure sources for tuber traits differ by variety. For instance, the Brown variety may respond better to sheep manure in terms of tuber multiplication, while the Yellow variety may benefit more from cattle manure to enhance tuber size. These findings are supported by Omokhua *et al.*, (2022), who observed significant ($p \leq 0.05$) variety × organic input interactions in root and tuber crops under varying agro-ecological zones. Yields were generally higher in 2019 than 2020 across all parameters. This is likely due to: Higher rainfall and humidity in 2019, facilitating nutrient mineralization and effective water uptake. In contrast, reduced rainfall and higher sunshine hours in 2020 may have stressed the plants during critical stages of tuber bulking, thereby reducing productivity. This emphasizes the importance of seasonal climatic factors in determining the efficacy of organic manure use and varietal performance (Ezeh *et al.*, 2020; Olaniyi and Adewale, 2021).

CONCLUSION

The application of organic manures significantly ($p \leq 0.05$) improved the yield and yield components of tigernut varieties compared to the control. This study revealed that tigernut varieties responded differently to manure sources, with poultry manure emerging as the most effective organic amendment for improving growth and yield traits. The interaction of tigernut variety and manure sources resulted in the highest fresh tuber yield recorded for the yellow variety at the application of poultry manure. The study concludes that poultry manure is a superior organic amendment for optimizing tigernut production, and its integration into tigernut farming systems with the cultivation of the yellow variety could sustainably enhance yield and soil health.

REFERENCES

Adekiya, A. O., Agbede, T. M., Ejue, W. S., & Olayanju, A. (2020). Comparative effects of organic and inorganic fertilizers on growth and yield of tigernut (*Cyperus esculentus* L.). *Acta Agriculturae Scandinavica, Section B — Soil & Plant Science*, 70(6), 493–500.

Adekiya, A. O., Agbede, T. M., Ejue, W. S., & Olayanju, A. (2020). Soil fertility and performance of tiger nut as influenced by organic and inorganic fertilizers. *Archives of Agronomy and Soil Science*, 66(5), 645–658.

Adekiya, A. O., Agbede, T. M., Olayanju, A. and Ejue, W. S. 2020. Integrated application of poultry manure and NPK fertilizer: Effects on soil chemical properties, growth, and yield of tigernut (*Cyperus esculentus* L.). *Communications in Soil Science and Plant Analysis*, 51(15): 2175–2188.

Adekiya, A. O., Ojeniyi, S. O., & Dunsin, O. (2021). Effects of poultry manure on soil chemical properties and performance of tuber crops in a derived savannah environment. *Journal of Agronomy*, 20(2), 103–109.

Adekiya, A. O., Ojeniyi, S. O., & Dunsin, O. (2021). Weather and organic inputs interactions in tigernut performance under rainfed conditions. *Journal of Agronomy and Crop Science*, 207(3), 522–529.

Aderibigbe, J. A., Alabi, M. A. and Ajayi, O. E. 2022. Climatic requirements and growth performance of tuber crops in the tropics: A review. *Journal of Agricultural Research and Development*, 22(1): 43–52.

Aderibigbe, J. A., Alabi, M. A., & Ajayi, O. E. (2022). Organic nutrient sources and their roles in sustainable root and tuber crop production in tropical environments. *Soil and Tillage Research*, 213, 105145.

Azeez, J. O., & Van Averbeke, W. (2022). Comparative effects of cattle, poultry, and goat manure on soil productivity in tropical cropping systems. *Soil Use and Management*, 38(2), 315–323.

Edeh, I. G., Okereke, G. U., & Oti, N. N. (2021). Effects of manure type on soil fertility improvement and maize yield in humid tropical soils. *Journal of Soil and Water Conservation*, 76(2), 213–221.

Edeh, I. G., Okereke, G. U., & Oti, N. N. (2021). Soil fertility restoration through integrated nutrient management in southeastern Nigeria. *Journal of Soil and Water Conservation*, 76(1), 49–58.

Edeh, J. O., Ude, G. N., & Nwakuba, N. R. (2022). Soil fertility restoration with organic manures for enhanced crop productivity. *African Journal of Agricultural Research*, 17(9), 1276–1284.

Eze, P. C., Ukoha, R. O., & Obi, M. U. (2022). Comparative effects of livestock manures on soil micronutrient dynamics and maize performance. *Tropical Agriculture (Trinidad)*, 99(1), 42–51.

Eze, P. C., Ukoha, R. O., & Obi, M. U. (2022). Organic manure-induced changes in soil micronutrients and their effects on crop performance. *Tropical Agriculture (Trinidad)*, 99(1), 42–51.

Ezeh, O., Ude, G. N. and Anozie, M. C. 2020. Environmental factors affecting tigernut growth and productivity in southern Nigeria. *African Journal of Plant Science*, 14(3): 90–97.

Ezeh, O., Ude, G. N., & Anozie, M. C. (2020). Genotypic variation in growth and development of tigernut in Nigeria. *African Crop Science Journal*, 28(1), 65–78.

Ibrahim, R. O., Okunade, D. A., & Bamidele, J. F. (2023). Use of organic mulch and poultry manure to mitigate climate variability on tuber yield of *Cyperus esculentus*. *Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension*, 22(2), 66–74.

Ibrahim, U., Yusuf, A. A., & Suleiman, M. M. (2020). Effect of light intensity on physiological responses and tuber yield of tigernut. *Scientific Journal of Agriculture*, 9(1), 18–25.

Ibrahim, U., Yusuf, A. A., & Suleiman, M. M. (2023). Effects of genotype and organic amendments on vegetative growth and tuber yield of tigernut (*Cyperus esculentus* L.). *Nigerian Journal of Soil and Plant Science*, 10(1), 25–34.

Ibrahim, U., Yusuf, A. A., & Suleiman, M. M. (2023). Organic amendment effects on the performance of tigernut varieties in northern Nigeria. *Nigerian Journal of Soil and Plant Science*, 10(1), 25–34.

labode, O. S., Etejere, E. O., & Ojeniyi, S. O. (2023). A review of soil fertility management through the application of animal manures. *Nigerian Journal of Soil Science*, 33(1), 15–25.

Nwite, J. N., Igwe, C. A. and Asawalam, D. O. 2021. Influence of poultry and cattle manure on soil properties and productivity of tuber crops. *International Journal of Organic Agriculture Research & Development*, 19(2): 34–45.

Nwite, J. N., Igwe, C. A., & Asawalam, D. O. (2021). Poultry manure influence on chemical properties of tropical soils and cassava yield. *Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension*, 20(2), 27–34.

Olabode, O. S., Etejere, E. O., & Ojeniyi, S. O. (2023). Soil fertility management using animal manures: A review of implications for sustainable crop production. *Nigerian Journal of Soil Science*, 33(1), 15–25.

Oladipo, B. R., Adewale, R. M., & Bello, A. K. (2023). Organic carbon and nutrient contribution of animal manures in arid zone soil fertility management. *International Journal of Agricultural Sustainability*, 21(1), 101–111.

Olaniyi, J. O. and Adewale, B. D. 2021. Varietal growth responses of tigernut under organic and conventional farming practices in southwestern Nigeria. *Nigerian Journal of Horticultural Science*, 26(1): 80–88.

Omokhua, G. E., Ogboghodo, I. A., & Ehiagbonare, J. E. (2022). Climate variability and crop performance in sub-humid agroecologies. *Agricultural Meteorology Research Journal*, 16(3), 55–64.

Omokhua, G. E., Ogboghodo, I. A., & Ehiagbonare, J. E. (2022). Rainfall variability and its influence on tigernut production in southern Nigeria. *Journal of Agricultural Meteorology*, 78(2), 125–132.

Onwudike, S. U. (2020). Comparative effects of different organic manures on soil quality and yield of root crops. *African Journal of Agricultural Research*, 15(5), 659–666.

Table 1: Physical and chemical properties of the soil (NACGRAB) before planting in 2019

Parameters	Pre-treatment
Physical properties	
Sand (%)	8.79
Silt (%)	4.3
Clay (%)	7.8
Textural class	Sandy – Loam
Chemical properties	
pH (H20)	5.69
Exchangeable bases	
Ca (cmolkg-1)	10.51
Mg(cmolkg-1)	1.49
K(cmolkg-1)	0.25
Na(cmolkg-1)	0.61
Al + H(cmolkg-1)	0.1
ECEC (cmolkg-1)	12.96
Base Saturation %	99.23
Total N %	0.13
Organic carbon %	0.66
Av. P (mgkg-1)	14.53
Micronutrients	
Mn (mgkg-1)	32.55
Fe (mgkg-1)	60.65
Cu (mgkg-1)	3.44
Zn (mgkg-1)	47.71

Table 2: Post planting analyses of the soil under different manure amendments (2020)

Soil properties	Cattle manure amended plot	Poultry manure amended plot	Sheep manure amended plot
Particle size			
Sand (%)	87.9	87.9	87.9
Silt (%)	4.3	4.3	4.3
Clay (%)	7.8	7.8	7.8
Textural class	Sandy loam	Sandy loam	Sandy loam
pH (H20)	6.8	6.9	6.7
Exchangeable bases			
Ca (cmol kg-1)	12.1	14.17	10.22
Mg (cmol kg-1)	3.2	3.54	2.5
k (cmol kg-1)	0.62	0.65	0.58
Na (cmol kg-1)	0.3	0.22	0.35
Al+H (cmol kg-1)	0.05	0.03	0.07
ECEC	16.27	18.76	11.8
Base saturation (%)	99.69	99.83	99.78
Total N (g kg-1)	2.5	2.6	2
Organic carbon (%)	1.54	1.55	1.5
Available P (mg kg-1)	17.21	18.23	15.65
Micronutrients			
Mn (mg kg-1)	29.36	27.24	27.22
Fe (mg kg-1)	46.43	30.46	51.41
Cu (mg kg-1)	2.65	2.32	2.21
Zn (mg kg-1)	37.24	32.36	29.14

Table 3: Physical and chemical properties of the manure used on the experimental site

Manure (Dried)	Cattle	Poultry	Sheep
pH	9.97	9.55	9.39
Ca (%)	1.13	1.71	1.46
Mg (%)	0.51	0.57	0.55
K (%)	1.2	0.78	0.86
Na (%)	0.35	0.18	0.23
Total N (%)	3.97	3.45	4.28
Total P (%)	0.19	0.34	0.2
Organic carbon (%)	14.88	9.97	17.57
Mn (mgkg-1)	955.23	209.56	261.75
Fe (mgkg-1)	5245.21	1230.86	4062.43
Cu (mgkg-1)	235.47	33.11	76.41
Zn (mgkg-1)	802.15	667.93	927.2
C/N Ratio	3.75	2.89	4.11

Table 4: Agrometeorological observations

Months	Total Rainfall (mm)		Mean Temperature (°C)		Relative Humidity (%)		Sunshine (Hours)	
Year	2019	2020	2019	2020	2019	2020	2019	2020
April	120.2	78.5	29.3	29.5	63.1	60.3	6.3	5.1
May	84.3	64.1	28.1	27.5	58.2	56.3	5.4	5.2
June	184.9	98.7	26.8	23.6	70.8	56.4	4.2	4.8
July	85.6	72.5	27.2	25.8	73	50.1	3.4	4.5
August	29.4	15.7	26.2	24.6	70.9	62.5	2.3	3.2
September	165.1	145.1	26.2	26.3	71.9	71.9	2.8	2.8
October	170	159.1	26.3	27.1	70.1	69.2	2.4	5.9
November	80.4	16.6	27.1	26.5	71.4	62.3	2.2	6.3
December	36.1	35	26.4	25.5	72.1	70.1	3.1	4
Total	956.1	685.3	243.6	236.4	621.5	559.1	32.1	41.8

Table 5: Effects of variety and manure sources on yield and yield parameters

Treatments	2019					2020				
Varieties (V)	Fresh Weight	Dry Weight	Number of tuber	Tuber diameter	100 Tuber weight	Fresh Weight	Dry Weight	Number of tuber	Tuber diameter	100 Tuber weight
Yellow	9.1	2.7	304.8	12.3	142.2	4.66	1.56	427	11.08	61.4
Brown	10.3	3	534.8	7.4	64.7	5.22	1.55	487	6.71	124.8
LSD($p \leq 0.05$)	0.56	0.13	15.74	0.4	28.13	0.55	Ns	ns	0.95	40.03
Sources (S)										
Cattle	9.8	2.8	418.2	9.8	91.4	4.87	1.75	391	8.97	79.5
Poultry	9.6	2.8	416.1	9.9	95.9	4.94	1.41	397	8.94	94
Sheep	9.5	2.9	425.1	10	123.1	4.99	1.5	583	8.78	105.8
LSD ($p \leq 0.05$)	ns	ns	ns	Ns	ns	ns	Ns	ns	0.09	ns
Interaction										
V x S	ns	ns	299.4	0.9	ns	Ns	Ns	ns	ns	ns

Ns- Not Significant (p<0.05), WAP- Week After Planting.

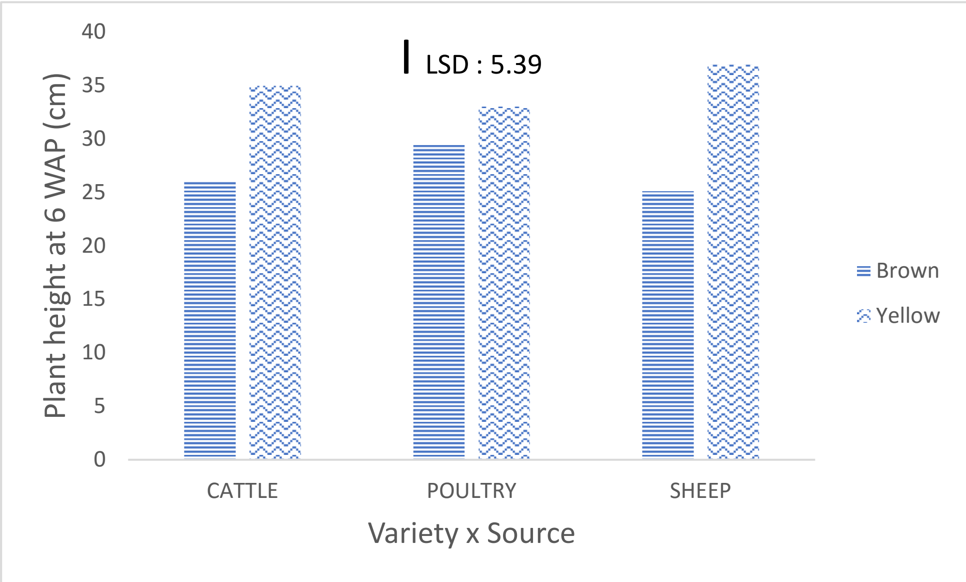


Figure 1: Interaction of variety × Source on plant height at 6 WAP in 2020.

Yield and yield components response of tigernut (*Cyperus esculentus* l.) varieties to organic amendment with different poultry manure rates

[1]Adeshola, T. A.*, [1]Fabunmi, T. O., [2]Adigbo, S. O., [3]Adejuyigbe, C. O., [4]Ajiboye, T., [1]Kasali, A. O. and [2]Fadeyi, O. J.

[1] Department of Plant Physiology and Crop Production, [2] Institute of Food Security, Environmental Resources and Agricultural Research (IFSERAR), [3] Department of Soil Science and Land Management
Federal University of Agriculture, Abeokuta, Ogun State, Nigeria
[4] National Centre for Genetic Resources and Biotecnology (NACGRAB), Oyo State, Nigeria

ABSTRACT

The search for sustainable and eco-friendly soil fertility management practices has underscored the importance of organic amendments in enhancing crop productivity. This study evaluated the agronomic performance of two tigernut (*Cyperus esculentus* L.) varieties in response to different rates of poultry manure application under field conditions. A 2 × 4 factorial experiment laid out in a randomized complete block design (RCBD) was conducted with three replicates. Treatments consisted of two tigernut varieties (Yellow and Brown) and four poultry manure rates (0, 3, 4, and 5 t/ha). Parameters assessed included yield and yield parameters such as fresh weight, dry weight, number of tuber, Tuber diameter and 100-tuber weight. Results indicated significant (($p \leq 0.05$) effects of poultry manure rates and variety on tuber yield and most yield parameters. Application of 5 t/ha poultry manure significantly ($p \leq 0.05$) improved tuber yield and yield attributes, especially in the yellow variety. The interaction between manure rate and variety revealed that yellow tigernut at 5 t/ha recorded the highest tuber yield. The study suggests that applying 5 t/ha poultry manure enhances tigernut productivity, particularly in the yellow variety, offering an eco-friendly strategy for improving tigernut yield in organic farming systems.

Key words: *Cyperus esculentus*, organic amendment, poultry manure, tuber yield

Corresponding author: titilolaadeshola@gmail.com;

INTRODUCTION

Tigernut (*Cyperus esculentus* L.), is commonly known as yellow nut sedge or "chufa" in Spanish, In Nigeria, it is known by various local names such as "ofioomu" (Yoruba), "haya" (Hausa), and "aki" (Igbo), reflecting its broad cultural relevance (Okafor *et al.,* 2003). Tigernut is widely consumed in parts of Africa, Europe, the Middle East, and Asia. It is a member of the *Cyperaceae* family, is an underutilized crop cultivated for its edible tubers, which are rich in dietary fiber, starch, lipids, and essential minerals (Adejuyitan, 2011; Musa and Hamza, 2013). Tigernut tubers are valued for their sweet, nutty flavor and are processed into beverages, flour, and oil with applications in food, pharmaceutical, and cosmetic industries (Abaejoh *et al.,* 2006; Adekiya *et al.,* 2020). It is also suitable for lactose-intolerant and gluten-sensitive populations. Despite its uses and nutritional benefits, tigernut remains largely neglected and underutilized in sub-Saharan Africa, where its production is constrained by poor soil fertility and suboptimal agronomic practices (Ndubuisi, 2009; Bamishaiye and Bamishaiye, 2011). Three main varieties are cultivated in Nigeria: black, brown, and yellow. Of these, the yellow variety is most preferred due to its larger size, higher milk yield, lower fat content, and reduced anti-nutritional factors such as polyphenols (Aremu *et al.,* 2016; Emuroti, 2017). Nonetheless, the agronomic performance of these varieties under varying fertility regimes remains underexplored. The use of organic amendments such as poultry manure has been recognized as a sustainable strategy for improving soil fertility, particularly in tropical regions where synthetic fertilizers are often expensive or poorly utilized (Adekiya *et al.,* 2020; Eifediyi *et al.,* 2022). Poultry manure is especially valued for its high nitrogen and phosphorus content, rapid mineralization, and positive impact on soil structure and microbial activity. While the benefits of organic manures on tuber and root crops such as cassava and sweet potato have been well documented (Ogunlela *et al.,* 2021), empirical data on their effects on tigernut varieties are limited. Previous research suggests that tigernut responds favorably to combine nutrient inputs, with higher yields achieved under integrated fertilizer management involving organic and inorganic sources (Adekiya *et al.,* 2020). Moreover, soil type and manure characteristics influence nutrient availability and crop uptake, necessitating context-specific evaluations (Smýkal *et al.,* 2015; Ofori *et al.,* 2023). Given the limited agronomic data on tigernut fertilization, especially with respect to variety-specific responses to organic amendments, this study was designed to assess the growth and yield performance of two tigernut varieties (yellow and brown) under varying poultry manure application rates. The goal is to determine optimal manure rates for sustainable tigernut production, with implications for low-input farming systems in sub-Saharan Africa.

MATERIALS AND METHODS

Location of the experiment

The experiment was conducted at the Nation al Centre for Genetic Resources and Biotecn ology (NACGRAB) in South West Local Go vernment Area of Oyo State, South Western Nigeria. The site lies within the rain-forest agro ecological zone of Nigeria. (Longitude 7°33[1]N and Latitude 3°56[1]E altitude) and 168 m above sea level. The research field of NACGRAB has been under continuous cultivation for more than 15 years.

Experimental treatments and design

The experiment was a 2 × 4 factorial experiment fitted into a Randomized Complete Block Design and the treatments consisted of three factors. Factor A; Two varieties (Yellow variety and Brown variety). Factor B; Four levels of poultry manure (0t/ha [control], 3t/ha (1.8kg/plot), 4t/ha (2.4kg/plot) and 5t/ha (3.0kg/plot), replicated three times. Gross plot size was 2 m × 3 m and an alleyway of 0.5 m within blocks and 1 m between blocks. The experiment conducted in late planting season of 2019 and early planting season of 2020.

Sources of animal manure:

Cured poultry manure was sourced from the Institute of Agricultural Research and training, Moor Plantation Ibadan.

Manure application:

Cured poultry manure (layers droppings), cow dung, and sheep dung were applied and incorporated with hoe 1 week before transplanting.

Nursery stage of the planting material:

Tigernut seedlings were primed by soaking th e tubers in water for 24 hours and then prege rminated with moistened sawdust for 1 week (Fabunmi *et al.,* 2016) before transplanting to the experimental field.

Planting date:

The healthy seedlings were transplanted a week after emergence at the rate of 1 seedling per hole and at the spacing of 0.5 m × 0.25 m in May 2019 and 2020 respectively.

Seedlings transplanting:

Transplanting of the tigernuts seedlings were done one week at the spacing of 0.50 m × 0.25 m having the plant population of 3,456 plant stands for each trial.

Cultural practices

The site was cleared of existing vegetation and stumped. Ploughing was done followed by harrowing, and the. It was there after marked into plots. The land was marked out into 3 replicates with 24 plots per block, making a total of 72 plots. Planting was done manually at a depth of about 5 cm for each seedling. Beds were raised with the height of 40 cm to achieve a uniform distribution and incorporation of the manure applied. The seedlings were planted on May 5th at NACGRAB, 2019 and 2020 respectively. Tigernut seedlings were transplanted at a spacing of 0.5m × 0.25m to give a population of 3,456 plant stands/ha. Replacement of missing stands (supplying) so as to achieve optimum plant population was done at one week after seedlings establishment. Wire mesh was used to surround the experimental field to prevent rodent intrusion. Weeding was done manually at 3, 6 and 9 weeks after planting to prevent negative effects of weeds on the cultivated crop.

Data collection

The following yield parameters were collected on tigernut plant:

Tuber yield and yield component: these were done within the net plot (2 m × 1 m) and expressed in tons per hectare, fresh weight was determined by weighing the tubers on a top load scale and recorded to compute tuber yield in tons per hectare; **Fresh and dry weight of tubers/plot (g):** fresh and dry weights was determined by weighing the tubers on a top load scale and recorded; **Number of tubers:** this was done by visual counting of tubers and was recorded; **Tuber girth (cm):** this was done by the use of a digital Vernier calliper to measure the girth of the tubers. Average tuber girth per plant was calculated and recorded per plot; **1000 tuber weight/Plot (g):** This was done by counting the tubers and weighed with the use of METTLER PM4000 scale; **Categorization of tubers:** This was done with the use of grading tray with the graduation holes of 12.07 mm (Fabunmi *et al.,* 2018) for the grading of tubers into small, medium and large.

RESULTS AND DISCUSSION

Effects of Variety and Manure Rates on Yield and Yield Parameters of Tigernut

Table 4 shows the effects of two tigernut varieties (Yellow and Brown) and varying poultry manure rates (3.0, 4.0, 5.0 t/ha, and a control) on fresh and dry tuber weight, number of tubers, tuber diameter, and 100-tuber weight across the 2019 and 2020 cropping seasons at NACGRAB. In both seasons, there were significant ($p \leq 0.05$) differences between the Yellow and Brown tigernut varieties for most yield components, although the direction of superiority varied by year. The Brown variety produced significantly ($p \leq 0.05$) higher fresh (10.3 t/ha) and dry weight (3.0 t/ha) than the Yellow variety (9.1 and 2.7 t/ha, respectively). It also recorded a greater number of tubers (534.8 per plant). However, Yellow had significantly ($p \leq 0.05$) larger tuber diameter (12.3 mm) and heavier 100-tuber weight (142.2 g), compared to Brown's 7.4 mm and 64.7 g, respectively. This suggests a trade-off between tuber quantity and size: Brown may favor numerous, smaller tubers, while Yellow produces fewer but larger and denser tubers. The observed differences align with previous findings that tuber yield components are highly genotype-dependent and reflect intrinsic resource allocation strategies (Ezeh *et al.,* 2020; Edeh *et al.,* 2022). Brown still outperformed Yellow in number of tubers and 100-tuber weight, but Yellow had slightly higher tuber diameter. However, no significant ($p \leq 0.05$) differences were found in dry weight or number of tubers, likely due to more erratic weather conditions, especially lower rainfall and humidity, which may have masked varietal differences (Olaniyi and

Adewale, 2021; Omokhua *et al.,* 2022). The application of poultry manure significantly ($p \leq 0.05$) influenced yield parameters in both years. The most consistent improvement across traits was observed at the 5.0 t/ha rate. Fresh tuber weight was highest at 5.0 t/ha (12.1 t/ha), significantly ($p \leq 0.05$) greater than the control (7.1 t/ha). Dry weight peaked at 3.6 t/ha under 5.0 t/ha poultry manure, compared to 2.0 t/ha in the control. Number of tubers and tuber diameter were also maximized at 5.0 t/ha (476.3 and 10.3 mm), although tuber diameter differences were not statistically significant ($p \leq 0.05$).Moreover, the 100-tuber weight was highest under 3.0 t/ha (120.7 g), followed by 5.0 t/ha with no significant ($p \leq 0.05$) differences across treatments. In 2020, fresh and dry weights remained significantly ($p \leq 0.05$) influenced by manure: 5.0 t/ha gave the highest fresh and dry weight yield. Tuber number peaked under 5.0 t/ha, again showing the nutrient-driven increase in reproductive output. Although tuber diameter and 100-tuber weight were not significantly ($p \leq 0.05$) different across treatments, trends showed improvement with increasing manure rates. The consistent positive effect of poultry manure at 5.0 t/ha suggests that nutrient-rich organic inputs significantly ($p \leq 0.05$) enhanced tigernut yield. Poultry manure contains readily available nitrogen, phosphorus, potassium, and beneficial micronutrients that support tuber formation and enlargement (Adekiya *et al.,* 2021; Nwite *et al.,* 2021). In addition, the organic matter improves soil structure, water-holding capacity, and microbial activity—factors crucial for tuber crops (Aderibigbe *et al.,* 2022).

Variety × manure rates interaction on tuber yield of tigernut

Figure 1 indicates that significant ($p \leq 0.05$) variety × manure rates interaction was observed in both years for tubers yield of tigernut in this study, indicating that the varieties responded differently to manure rates. This interaction indicated the highest tuber yield of 11.0 t/ha and 6.2 t/ha, both years respectively at 5.0 t ha^{-1} manure application particularly for Brown. This finding underscores the importance of considering genotype × environment × management interactions in optimizing yield in organic-based systems (Olaniyi & Adewale, 2021). These conditions supported better manure mineralization and nutrient uptake, translating into enhanced vegetative and reproductive growth (Omokhua *et al.,* 2022).

CONCLUSION

This study demonstrated that tigernut yield and yield parameters were influenced by both variety and poultry manure rates. The manure application rate of 5.0 t ha^{-1} optimally improved the yield and yield components of tigernut. The Brown variety demonstrated superior yield potential between the two tested varieties, under organic amendments. Consequently, application of 5.0 t ha^{-1} poultry manure on brown tigernut variety is recommended for potential resource-constrained organic tigernut farmers.

REFERENCES

Abaejoh, R., Djomdi, I. andNdjouenkeu, R. (2006). Characteristics of tigernut (*Cyperus esculentus*) tubers and their implications for nutrition. *Journal of Food Technology*, 4(2), 151–155.

Adekiya, A. O., Agbede, T. M., Olayanju, A., &Ejue, W. S. (2020). Integrated application of poultry manure and NPK fertilizer: Effects on soil chemical properties, growth, and yield of tigernut (*Cyperus esculentus* L.).

Communications in Soil Science and Plant Analysis, 51(15), 2175–2188.

Adekiya, A. O., Agbede, T. M., Olayanju, A., &Ejue, W. S. (2020). Integrated application of poultry manure and NPK fertilizer: Effects on soil chemical properties, growth, and yield of tigernut (*Cyperus esculentus* L.). *Communications in Soil Science and Plant Analysis*, 51(15), 2175–2188.

Adekiya, A. O., Ojeniyi, S. O., &Dunsin, O. (2021). Weather and organic inputs interactions in tigernut performance under rainfed conditions. *Journal of Agronomy and Crop Science*, 207(3), 522–529.

Aremu, M. O., Ibrahim, H., & Bamidele, T. O. (2016). Physicochemical and functional properties of tigernut (*Cyperus esculentus*) seed flour as influenced by varieties. *Food and Public Health*, **6**(1), 1–6

Bamishaiye, E. I., & Bamishaiye, O. M. (2011). Tigernut: As a plant, its derivatives and benefits. *African Journal of Food, Agriculture, Nutrition and Development*, 11(5), 5157–5170.

Edeh, J. O., Ude, G. N., &Nwakuba, N. R. (2022). Response of two varieties of cocoyam to organic fertilizer application in Southeastern Nigeria. *Nigerian Journal of Crop Science*, 9(1), 54–62.

Eifediyi, E. K., Remison, S. U., & Okunlola, F. O. (2022). Organic amendments and their effects on soil fertility and crop performance. *Nigerian Journal of Soil Science*, 32(1), 45–53.

Emuroti, M. A. (2017). Nutritional assessment of tigernut varieties and its potential as a substitute crop. *International Journal of Agricultural Science*, **7**(4), 55–61.

Ezeh, O., Ude, G. N., &Anozie, M. C. (2020). Environmental and varietal effects on vegetative development and yield in tigernut. *African Journal of Plant Science*, 14(3), 90–97.

Ndubuisi, E. C. (2009). Potential of tigernut in sustainable agriculture and food security in Nigeria. *Nigerian Agricultural Journal*, 40(1), 128–133.

Nwite, J. N., Igwe, C. A., &Asawalam, D. O. (2021). Poultry manure application: Effects on soil fertility and yield of maize and cassava intercropping system. *Agricultural Research and Technology*, 27(3), 556358.

Ofori, E. J., Asante, M. O., &Kyei-Baffour, N. (2023). Comparative effects of organic manures on soil quality and yield of root crops in Ghana. *West African Journal of Soil Science*, 4(1), 21–29.

Ogunlela, A. O., Osho, I. B., &Ajiboye, A. T. (2021). Enhancing cassava productivity using poultry and cattle manures. *Journal of Agronomy*, 20(3), 200–207.

Okafor, J. C., Okolo, H. C., & Okezie, C. A. (2003). Indigenous knowledge and the use of tigernut in Nigeria. *Nigerian Journal of Botany*, 16, 149–158.

Olaniyi, J. O., & Adewale, B. D. (2021). Climatic influences on vegetative growth and productivity of tigernut (*Cyperus esculentus*) in southwestern Nigeria. *Nigerian Journal of Ecology*, 29(2), 88–98.

Omokhua, G. E., Ogboghodo, I. A., &Ehiagbonare, J. E. (2022). Rainfall variability and its influence on tigernut production in southern Nigeria. *Journal of Agricultural Meteorology*, 78(2), 125–132.

Smýkal, P., Vernoud, V., Blair, M. W., &Soukup, A. (2015). The role of organic inputs on tuber crops in Africa. *Field Crops Research*, 176, 42–52.

Table 1: Physical and chemical properties of the soil (NACGRAB) before planting in 2019.

Parameters	Pre-treatment
Physical properties	
Sand (%)	87.9
Silt (%)	4.3
Clay (%)	7.8
Textural class	Sandy loam
Chemical properties	
pH (H_20)	5.69
Exchangeable bases	
Ca (cmolkg^{-1})	10.51
Mg(cmolkg^{-1})	1.49
K(cmolkg^{-1})	0.25
Na(cmolkg^{-1})	0.61
Al + H(cmolkg^{-1})	0.10
ECEC (cmolkg^{-1})	12.96
Base Saturation %	99.23
Total N %	0.13
Organic carbon %	0.66
Av. P (mgkg^{-1})	14.53
Micronutrients	
Mn (mgkg^{-1})	32.55
Fe (mgkg^{-1})	60.65
Cu (mgkg^{-1})	3.44
Zn (mgkg^{-1})	47.71

Table 2: Physical and chemical properties of the manure used on the experimental site (NACGRAB) before planting in 2019 and 2020.

Parameters	Poultry Manure
pH	9.55
Ca (%)	1.71
Mg (%)	0.57
K (%)	0.78
Na (%)	0.18
Total N (%)	3.45
Total P (%)	0.34
Organic carbon (%)	9.97
Mn (mgkg^{-1})	209.56
Fe (mgkg^{-1})	1230.86
Cu (mgkg^{-1})	33.11
Zn (mgkg^{-1})	667.93
C/N Ratio	2.89

Table 3: Agrometeorological observations

Months	Total Rainfall (mm)		Mean Temperature (° C)		Relative Humidity (%)		Sunshine (Hours)	
	2019	2020	2019	2020	2019	2020	2019	2020
April	120.2	78.5	29.3	29.5	63.1	60.3	6.3	5.1
May	84.3	64.1	28.1	27.5	58.2	56.3	5.4	5.2
June	184.9	98.7	26.8	23.6	70.8	56.4	4.2	4.8
July	85.6	72.5	27.2	25.8	73.0	50.1	3.4	4.5
August	29.4	15.7	26.2	24.6	70.9	62.5	2.3	3.2
September	165.1	145.1	26.2	26.3	71.9	71.9	2.8	2.8
October	170.0	159.1	26.3	27.1	70.1	69.2	2.4	5.9
November	80.4	16.6	27.1	26.5	71.4	62.3	2.2	6.3
December	36.1	35.0	26.4	25.5	72.1	70.1	3.1	4.0
Total	956.1	685.3	243.6	236.4	621.5	559.1	32.1	41.8

Table 4: Effect variety and manure rate on yield and yield parameters

	2019					2020				
	Fresh weight (g)	Dry Weight (g)	Number of tuber	Tuber diameter	100 Tuber weight (g)	Fresh Weight (g)	Dry Weight (g)	Number of tuber	Tuber diameter (cm)	100 Tuber weight (g)
Varieties (V)										
Yellow	9.1	2.7	304.8	12.3	142.2	4.66	1.56	427	11.08	61.4
Brown	10.3	3	534.8	7.4	64.7	5.22	1.55	487	6.71	124.8
LSD ($p \leq 0.05$)	0.56	0.13	15.74	0.4	28.13	0.55	Ns	ns	0.95	40.03
Rates (R)										
3.0 t/ha	9.2	2.5	384.3	9.6	120.7	6.24	1.36	476	8.92	93.6
4.0 t/ha	10.6	3.3	456.5	10.1	97.9	4.44	1.94	297	8.21	89.5
5.0 t/ha	12.1	3.6	476.3	10.3	106.1	5.74	1.95	593	9.42	104.8
Control	7.1	2	362.1	9.5	89.1	3.32	0.97	461	9.04	84.6
LSD ($p \leq 0.05$	0.79	0.188	22.26	0.56	ns	0.28**	0.57*	ns	0.35	ns
Interaction										
V x R	9.1	2.7	31.51	ns	ns	4.66	1.56	ns	0.72	38.28

Ns- Not Significant ($p > 0.05$), WAP- Week after Planting.

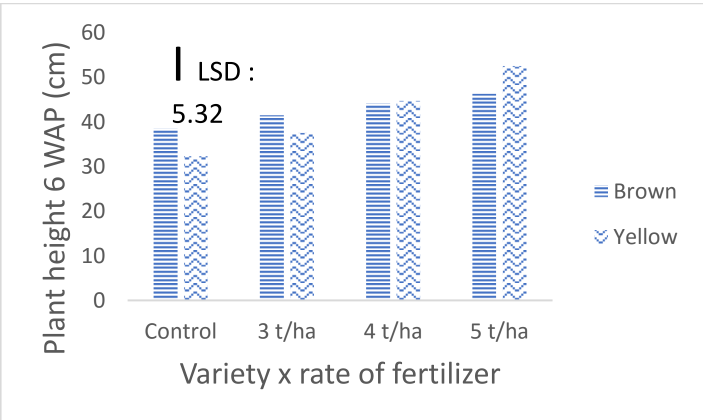


Figure 1: Interaction of variety × rate of fertilizer on plant height at 6 WAP in 2019.

Postharvest characteristics of cabbage (*Brassica oleracea* l. var capitata) stored in the evaporative cooling system

Oreagba, O. R., Odeyemi, O. M. and Ajibola, O. W.

Department of Horticulture, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria

ABSTRACT

Improved post-harvest storage plays a vital role in preserving the quality and extending the shelf life of cabbage, a nutritious and widely consumed vegetable. An experiment was conducted using Evaporative Cooling System (ECS) as a storage medium for cabbage in the Department of Horticulture, Federal University of Agriculture, Abeokuta (FUNAAB). The aim of the experiment was to determine the biochemical composition and identify fungi and bacteria associated with cabbages stored in the ECS. Cabbage (Attila F1) used in the experiment was sourced from Agricwas Farm and Agro-business Consultancy, located in Aboke village, Ibadan. The cabbages were harvested in the morning and allowed to cool down for two hours to reduce field heat before they were transported to the laboratory in FUNAAB. The treatments were two storage environment- ECS and the open shelf. Three crates containing four cabbages each were stored in both the ECS and the open shelf. The ECS was watered daily to maintain cooling effects for 17 days and an average temperature of 25 °C and 35 °C with relative humidity of 89 % and 72 % was observed in both the ECS and open shelf respectively. The experiment was laid out in a completely randomized design with three replicates. Data collected before and after storage included: weight loss, color change, vitamin C and K contents, Total Soluble Solids (TSS), and microbial (fungi and bacteria) identification and count. These data were analyzed using a Student's T-test at $p \leq 0.05$ with R-project statistical software. Results showed that cabbages stored in the ECS had higher TSS value with increased vitamin K content with storage but reduced vitamin C content; *Staphylococcus epidermidis* and *Aspergilus flavus* were the bacteria and fungi identified in non-significant count in cabbages stored in the ECS. However, *Staphvlococcus epidermidis, Pseudomonas areuginosa* and *Aspergillus flavus, Aspergilus niger* were the bacteria and fungi respectively identified in significant count in the open shelf when compared with those found on cabbages in the ECS. Moreso, cabbages stored in the open shelf showed significant weight loss, greater color deterioration, lower Vitamin C and TSS contents when compared with cabbages stored in the ECS. In conclusion, cabbages stored in the ECS were sweeter with reduced weight loss, more vitamin K content but with reduced vitamin C content. *Staphylococcus spp* and *Aspergillus flavus* were also present in non-significant count on the cabbages.

Keywords: bacteria and fungi growth, vegetable, quality, shelf life, storage

Corresponding author: odeyemiom@funaab.edu.ng

INTRODUCTION

Cabbage (*Brassica oleracea* L. var capitata) is one of the most popular cultivars of the family Brassicaceae (also known as Cruciferae) grown around the world (Inthuja *et al.,* 2019). Despite its popularity, cabbage is highly perishable and prone to post-harvest losses caused by mechanical damage, microbial spoilage, and physiological changes such as wilting and yellowing (Morales *et al.*, 2017). These losses contribute to reduced economic value and food availability, highlighting the need for effective storage system. Traditional storage methods often fail to maintain the post-harvest quality of cabbage due to fluctuations in temperature and humidity, making refrigeration a challenging option due to the susceptibility of cabbage to chilling injury (Jones *et al.,* 2015). Evaporative cooling offers a promising, cost-effective alternative for short-term preservation by leveraging the natural process of evaporation to reduce temperature and maintain optimal humidity levels (Iqbal and Ahmad, 2020). This method slows down deterioration by minimizing weight loss and preserving freshness, ultimately extending the shelf life of cabbage and reducing overall wastage (Adams *et al.,* 2016).

This study shows the effectiveness of evaporative cooling in preserving the post-harvest quality of cabbage by analyzing factors such as weight loss, color retention, nutrient composition, and microbial load. By comparing cabbage stored in an evaporative cooling system with those placed on open shelves, the research aims to demonstrate the advantages of this storage method (Chaudhary *et al.,* 2022). Findings from this study could provide valuable insights for farmers and agricultural stakeholders, promoting the adoption of sustainable storage solutions that minimize post-harvest losses and enhance food security (Smith *et al.,* 2010). This study aims to assess the biochemical composition and shelf life of cabbage stored in an evaporative cooling system. Additionally, it seeks to identify the fungi and bacteria present in cabbage under these storage conditions, providing insights into the microbial dynamics affecting post-harvest quality.

MATERIALS AND METHODS

The study was conducted in November 2024 at the Laboratory of the Department of Horticulture, Federal University of Agriculture, Abeokuta. Fresh cabbages (Attila F1) were sourced from Agriwas Farm in Ibadan. The cabbages were harvested in the morning and cooled down for two hours to reduce field heat after which they were transported to FUNAAB. They were cleaned and sterilized on arrival at FUNAAB and placed in plastic crates (three crates containing four cabbages) and placed in two different storage environments—an open shelf and an ECS. The ECS was watered daily to maintain cooling effects for 17 days and an average temperature of 25 °C and 35 °C with relative humidity of 89 % and 72 % was observed in both the ECS and open shelf respectively. The experiment was laid out in a completely randomized design with three replicates.

Data collected before and after storage included: weight loss Color change using a colorimeter, Vitamin K and Vitamin C levels using spectrophotometric and titration methods, respectively while Total Soluble Solids (TSS) was determined using a refractometer. Microbial analysis (bacteria and fungi) identification and count counts were determined with samples sterilized, diluted, and cultured on nutrient agar and potato dextrose agar. Plates were incubated at specified temperatures for bacteria (37ºC) and fungi (28ºC), and colony counts were manually recorded. Bacterial isolates were subjected to Gram staining and biochemical characterization, while fungal identification was determined using colony morphology and microscopic analysis using lactophenol cotton blue staining. Statistical analysis was conducted using a student t-test with a significance level of $p \leq 0.05$ via R-project statistical software.

RESULTS AND DISCUSSION

Color of cabbage as influenced by storage medium

The results showed that the L* and a* values obtained for cabbages at pre-storage and after storage in the ECS and open shelf was comparable. However, the b and b* values (yellow value) was significantly higher in cabbages at pre-storage when compared with values obtained after storage in the ECS and open shelf. This showed that yellowness in the cabbage reduced significantly with storage in both the ECS and open shelf (Figure 1).

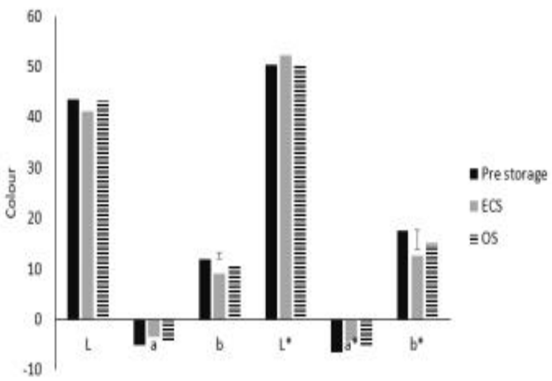


Figure 1: Color of cabbage stored at pre and post storage (ECS and open shelf).
L - Lightness of the cabbage (0-100), a-redness (+ve) or greenness (-ve) of cabbages b- blueness (-ve) or yellowness (+ve) of cabbage. ECS- Evaporative cooling system. OS- Open shelf

Biochemical composition of cabbage as influenced by storage medium

The study revealed that freshly harvested cabbage had the highest total TSS, which declined after storage in both the ECS and the open shelf. The decline in TSS in cabbage during storage could be as a result of respiration and other metabolic processes that convert sugars into energy. Similar findings were observed by Inthuja *et al.,* (2019) during storage of cabbage under ambient condition However, cabbage stored in the ECS retained more TSS than those stored on the open shelf, demonstrating the ECS's superior ability to preserve quality (Figure 2). Vitamin K content increased after storage in both environments, with cabbage stored on the open shelf showing slightly higher levels than those in the ECS. This increase was attributed to moisture loss, which concentrated Vitamin K in the open shelf stored cabbage. Both storage methods proved effective in maintaining or enhancing certain nutrients (Figure 3). Vitamin C levels were highest in cabbages before storage but declined significantly afterward. Cabbage stored in the ECS retained more Vitamin C than those stored on the open shelf, highlighting the ECS's effectiveness in preserving this nutrient. Overall, the results indicate that the ECS is a better storage method for maintaining TSS and Vitamin C while also providing a stable environment for nutrient retention (Figure 4).

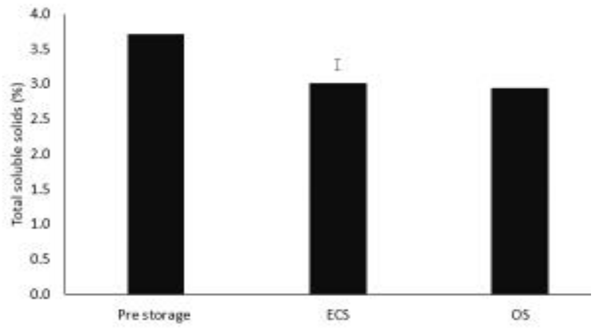


Figure 2: Total soluble solids content of cabbage as influenced by storage environment
ECS- Evaporative cooling system. OS- Open shelf

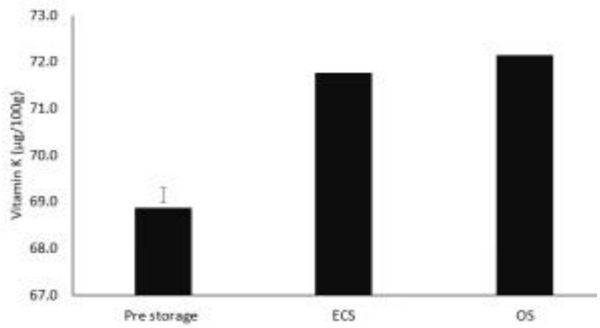


Figure 3: Vitamin K content of cabbage stored as influenced by storage environment
ECS- Evaporative cooling system. OS- Open shelf

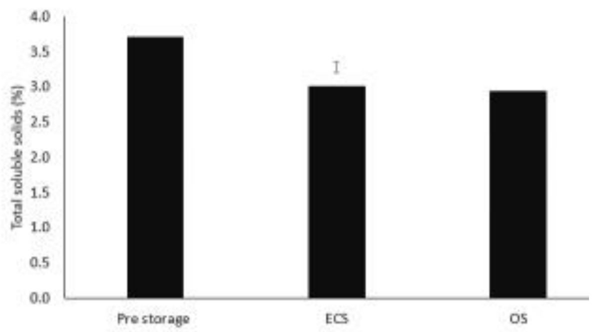


Figure 4: Vitamin C contents (mg/100g) of cabbage as influenced by storage environment
ECS- Evaporative cooling system. OS- Open shelf

Microbial identification and count in cabbage as influenced by storage medium

Cabbages stored on the open shelf had significantly higher bacterial and fungal counts compared to those in the evaporative cooling system (ECS). *Staphylococcus epidermidis* was present across all storage conditions but was more significant in OS-stored cabbages, while *Pseudomonas aeruginosa* appeared only in open shelf storage. No bacterial growth was observed in ECS cabbage, indicating its role in slowing contamination and prolonging shelf life (Figure 5). Fungal analysis showed that *Aspergillus flavus* and *Aspergillus niger* were abundant in open shelved cabbage but significantly lower in ECS storage. No fungi were detected in pre-storage samples, confirming that contamination occurred during storage. Bamkefa *et al.,* (2022) during their study to determine the microbial profile on samples of cabbage sold in selected markets in Ibadan identified both fungi and bacteria. Fungi isolated included; *Sclerotina sp, Fusarium sp, Cladosporium sp, Aspergillus sp, Mucor sp, Alternaria sp and Rhizopus sp.* while bacteria isolated included; *Staphylococcus sp, Pseudomonas sp, Xanthomonas sp, Micrococcus sp, Bacillus sp, Erwinia sp and Streptococcus sp.* However, the ECS, with its lower temperature and higher humidity, effectively inhibited microbial proliferation, reducing spoilage risks and maintaining cabbage quality (Figure 6).

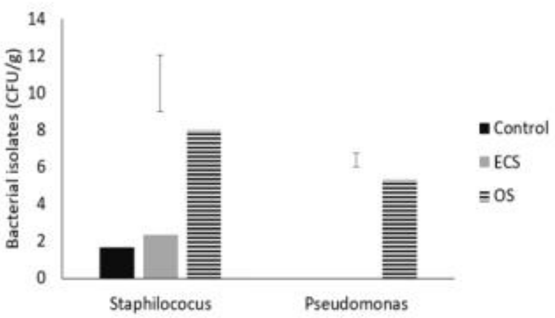


Figure 5: Bacteria identification and count in cabbage as influenced by storage environment
ECS- Evaporative cooling system. OS- Open shelf

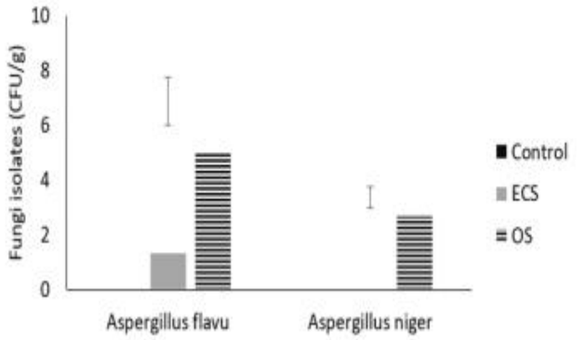


Figure 6: Fungi identification and count on cabbage as influenced by storage environment
ECS- Evaporative cooling system. OS- Open shelf

Weight loss in cabbage as influenced by storage medium

Results also showed that cabbage stored in the OS experienced consistently higher weight loss when compared with cabbages stored in the ECS. This difference became more apparent as the storage duration increased. These results shows that ECS effectively slowed down moisture loss from cabbage by maintaining a cooler and more humid microclimate. Similar findings was observed by Odeyemi *et al.,* (2014) on their study on three different varieties of pawpaw stored in the ECS and ambient environment. Reduced water loss leads to better freshness, texture, and marketability of the produce while the open shelf, exposed to ambient conditions, results in faster dehydration and spoilage. (Figure 7)

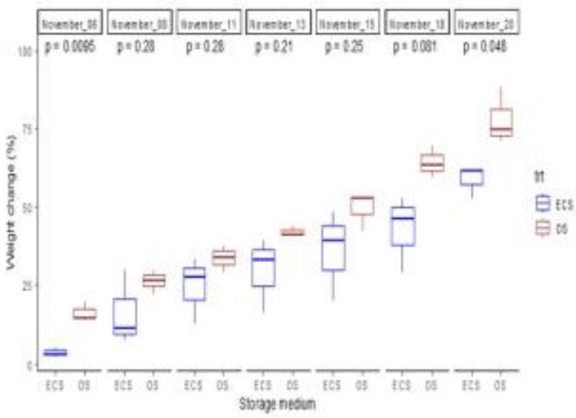


Figure 7: Weight loss (%) in cabbage as influenced by storage environment

CONCLUSION

The ECS maintained sweetness and vitamin K content in cabbages but reduced Vitamin C content within the 17 days of storage. More so cabbages stored in the ECS had reduced weight loss due to the reduced temperature coupled with high humidity level providing a cool environment. *Staphylococcus epidermis* and *Aspergillus flavus* were the bacteria and fungi identified respectively in the cabbages stored in the ECS however the count was insignificant.

REFERENCES

Adams, C., Taylor M. and Hassan F. 2016. Evaporative Cooling and its Application in Food Storage. *Journal of Sustainable Agriculture,* 40(3): 320–334.

Bamkefa, B. A., Umezurike, E. T., Oluboyede, O. and Adegbehingbe, K. 2022. *GSC Biological and Pharmaceutical Sciences,* 21(03): 166-174

Chaudhary, Farah, Singh, Anil, and Narayan, Suresh. 2022. Comparative study of traditional and modern storage methods. *Critical Reviews in Food Science and Nutrition,* 57(6): 275-295.

Inthuja, J., Mahendran, T. and Jemziya, M. B. F. 2019. Storage stability of functional RTS beverage contrived from headed white cabbage (*Brassica oleracea.* L) and Key Lime (*Citrus x aurantifolia*). *International Food Research Journal,* 26(3): 877-881

Iqbal S. and Ahmad M. 2020. Evaporative Cooling Systems for Perishable Crops. *International Journal of Food Preservation*, 42(1): 89–102.

Jones, A., Clark, D. and Wilson, P. 2015. The Role of Evaporative Cooling Storage Technology to Reduce Post-Harvest Losses of Fruits and Vegetables: A Review. *Food Science and Nutrition Technology,* 18: 66-70.

Morales L. J., Centeno A. M., Nieto C. A., Lopez M. G, Perez A. E. and Perez H. N., 2007. Evaluation of antioxidant and hepatoprotective effects of white cabbage essential oil. *Pharmaceutical Biology,* 55(1): 233-41.

Odeyem,i O. M., Aiyelaagbe, I. O. O., Bodunde, J. G. and Babalola, S. O. 2014. Influence of variety and production system on postharvest quality of pawpaw (*Carica papaya.* L) fruits stored in different Media. *Nigerian Journal of Horticultural Science,* 19: 53-60.

Smith, J., Brown, R. and Taylor, M. 2010. Evaporative Cooling: A Postharvest Technology for Fruits and Vegetables Preservation. *International Journal of Scientific & Engineering Research,* 65: 202-210.

Soil suitability assessment for watermelon (*Citrillus lanatus* l.) using parametric model

Osinuga, O. A., Osoiwanlan, P. E., Olaegbe, T. J., Orunmuyi, T. J., Adewale, B. I. and, K. I.
Department of Soil Science and Land Management
Federal University of Agriculture, Abeokuta, Ogun State, Nigeria

ABSTRACT
Agricultural land use and productivity are fundamentally connected to soil suitability assessment. The study aimed to optimise watermelon cultivation through advanced soil suitability assessment using a parametric model. Detailed surveys of the soils of the CEADESE farm at the Federal University of Agriculture, Abeokuta, were carried out using a rigid grid soil survey method. The soils were delineated into three mapping units based on the vegetation and land types. The soils were well-drained with loamy sand to sandy clay texture and were moderate in bulk density (1.17–1.42 g/cm^3), low Ksat (0.67–2.94 cm/hr), slightly acid to neutral pH (5.60–6.68), low to moderate OC (0.63–3.03%), low total nitrogen (0.02–0.26%), low phosphorus (0.83–8.75 mg/kg), low ECEC (1.51–4.96 cmol/kg), high base saturation (95.51–99.11%), and low EC (12–44 µS/cm). The index of current productivity (IPc) by linear model ranged between 41.7 and 48.5, while by square root models ranged between 43.8 and 52.6. The values suggested the soils were marginally (S3) for watermelon production. The index of potential productivity (IPp) was 80.8 for the linear model and 82.8 for the square root model. Thus, the soils were potentially moderately (S2) suitable for watermelon production. The limiting factors identified were low soil fertility, especially total nitrogen, available P, exchangeable K, and ECEC. Climate, topography, and wetness are good, but soil fertility and nutrient management need improvement for better watermelon cultivation. With the adequate application of appropriate fertilisers and suitable soil management, the productivity of the land will be optimally enhanced for pineapple yield and quality.

Keywords: Agriculture, Land use, Parametric, Soil characteristics, Soil models, Watermelon

***Corresponding author**: …..

INTRODUCTION
Agricultural productivity is intrinsically linked to the suitability of the soil in which crops are cultivated (Shah and Wu, 2019). Soil suitability, defined as the ability of a particular soil type to support the growth of a specific crop, plays a pivotal role in determining crop health, yield, and overall sustainability (Osinuga *et al.*, 2020). As the global population grows and food security becomes an increasingly pressing concern, understanding and optimising soil suitability becomes imperative for sustainable agriculture practices. Different crops exhibit specific preferences for soil conditions, including texture, structure, nutrient content, and drainage capacity. The concept of soil suitability extends beyond mere plant survival to optimising factors such as nutrient uptake, water utilisation, and resistance to pests and diseases. In the contemporary context of precision agriculture, where resource efficiency and environmental sustainability are paramount, understanding and optimising soil suitability have taken centre stage (Brady and Weil, 2008).

Traditional soil suitability assessments often lack the precision necessary for modern agriculture, resulting in suboptimal yields, resource inefficiencies, and adverse environmental impacts. Parametric analysis enables the collection and utilisation of quantitative data on key soil parameters, providing a more objective and measurable basis for soil suitability assessment (Karlen *et al*., 1997). The parametric analysis model offers a structured framework to prioritise different soil parameters based on their relative importance to crop cultivation, ensuring a more precise and accurate assessment of soil suitability and facilitating informed decision-making (Saaty, 1980; Lal, 2015). To address existing limitations in traditional soil suitability assessments and enhance precision in decision-making for watermelon farmers, the integration of the parametric analysis model seeks to improve precision and effectiveness in determining optimal soil conditions for watermelon cultivation. Therefore, the objectives of the study were to characterise and assess the suitability of the soils of the study area for watermelon using a parametric model.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted at the Centre of Excellence in Agriculture Development and Sustainable Environment (CEADESE) farm and the Pasture and Range Department paddock in the Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. The area falls within Latitude 07°13'20"N and 07°13'30"N and Longitude 03°25'40"E and 03°26'20"E (Figure 1). Geologically, the study area falls within the Precambrian rocks of southwest Nigeria, basically from the Basement Complex rock origin. The major rock types are schist, quartz, granite, gneiss, and migmatite (Aiboni, 2001; Osinuga *et al*., 2020). The climate falls within the derived savannah ecology with two seasons: wet season (March-November) and dry season (December-Early March). The area has a mean annual rainfall of 1000-1500 mm, a mean temperature of 26-34°C, a mean relative humidity of 75-95%, and potential evapotranspiration of 218-274 mm (FUNAAB Weather Report, 2022).

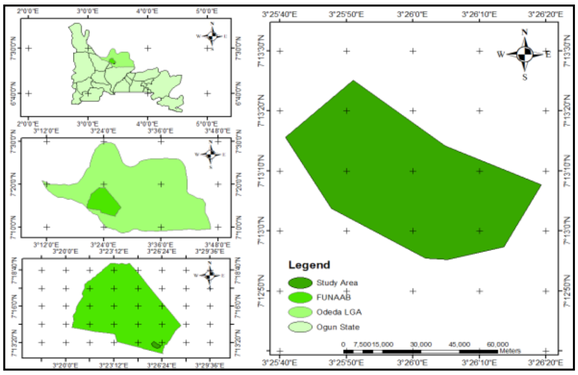


Figure 1: Map of Ogun State Nigeria showing the study area

Pedological Studies

Auger observations were made at increments of 20 cm to record soil morphological characteristics (depth, drainage, colour, texture, structure, consistence, and root distribution) to a depth of 120 cm. Based on similarities and differences observed from the auger samples, the area was delineated into three mapping units for a more detailed study. One modal profile pit was dug in each of the mapping units and described according to guidelines for soil description (World Reference Base (WRM), 2022). Bulk and composite soil samples for analysis were collected from horizons identified in these pits and air dried at room temperature for laboratory analysis.

Laboratory Analysis

The air-dried soil samples were sieved and subjected to routine soil analysis. Particle size fraction analysis was determined by the mechanical analysis technique (Gee and Bauder, 1986). Soil pH was measured potentiometrically in a soil water suspension using a glass electrode pH meter. Organic carbon (OC) was determined by the dichromate wet oxidation method of Walkley and Black (Nelson and Sommers, 1996). Total nitrogen (TN) was determined by the micro-Kjeldahl digestion method. Available phosphorus (P) was extracted by Bray-1 solution, and the colour was developed in soil extract using the ascorbic acid blue method (Murphy and Riley, 1962). Exchangeable bases (Ca, Mg, Na, and K) were extracted by saturating the soil with neutral 1M NH_4OAc (Thomas, 1982). Ca and Mg in the extract were determined using AAS, while Na and K were determined by flame photometry. Exchangeable acidity was determined by extracting the soil with 0.17 M KCl solution and titrating the aliquot of the extract with I N NaOH (Udo *et al.*, 2009). Effective cation exchange capacity (ECEC) was determined by the summation of exchangeable bases and acids. Base saturation was calculated as the ratio of the sum of total exchangeable bases to NH_40Ac cation exchange capacity, expressed as a percentage (Page *et al.*, 1982).

Land Suitability Evaluation

The parametric land evaluation consists of a numerical rating of different land characteristics according to a numerical scale between the maximum and the minimum value. The climatic indices and the land index were calculated from these individual ratings. The current suitability was computed linearly using an index of current (actual) productivity (IPc) of Storie (1978):

$$IPc = A \times \frac{B}{100} \times \frac{C}{100} \times \frac{D}{100} \times \frac{E}{100} \times \frac{F}{100} \quad \text{----- (i)}$$

(c) (t) (w) (s) (f)

IPc is an index of current (actual) productivity, A is the overall least rating characteristic, and B, C….F are the least rating characteristics for each land quality group. The potential suitability (IPp) was similarly computed using the potential index of productivity. The IPc and IPp were also computed using the square root model as stated below:

$$IPc = A \times \sqrt{\frac{B}{100} \times \frac{C}{100} \times \frac{D}{100} \times \frac{E}{100} \times \frac{F}{100}} \quad \text{----- (ii)}$$

(c) (t) (w) (s) (f)

Statistical Analysis

The soil data were analysed using descriptive statistics to show the relationship of the variables in the study location. The mean was used to determine the average distribution of the variables.

RESULTS

Pedological Properties of the Soils

The morphological and physical characteristics of the representative profiles across the three mapping units reveal variations in texture, structure, colour, consistency, root abundance, and bulk density (Table 1). The soils were generally deep (>100 cm) and were well-drained, exhibiting no sign of flooding. The profile samples indicated that the soils had different textures ranging from loamy sand to sandy clay, with medium to coarse texture dominating. The soil colours differ from one mapping unit to another, with surface horizons colour ranging from very dark greyish brown (10YR3/2) to greyish brown (10YR5/2), and the subsoil horizons between brown (10YR5/3) to yellowish brown (5YR5/4). The soil's structures were mostly subangular blocky with weak to strong grades and fine to coarse classes. The particle size distribution showed that the soils had high sand content (> 590 g/kg) and decreased with depth, and the values ranged from 594 to 864 g/kg. The silt contents in the soils were generally low, and ranged from 16 to 86 g/kg, while the clay fraction of the soil particles ranged between 110 and 360 g/kg and increased with depth. The soil texture varied between loamy sand (LS) to sandy loam (SL) at the upper horizons, while at the lower horizons, it varied between sandy loam (SL) to sandy clay loam (SCL). The bulk density of the soils increased with soil depth. The bulk density values ranged from 1.17 to 1.42 g/cm^3 in the study sites. Statistical analysis showed a significant ($p \leq$

0.05) difference in the mean profile bulk density (Table 1). The saturated hydraulic conductivity (Ksat.) values ranged from 0.67 to 2.94 cm/hr in all the profiles. The soil porosity increased with the soil depth following the bulk density trend; the lowest value recorded was 43.28%, and the highest value was 52.58%.

The chemical characteristics of the soils are depicted in Table 2. The soil pH (H_2O) ranged from slightly acid to neutral (5.60 – 6.68), and strongly acid to moderately acid (3.68 – 5.05) in KCl. In all the profiles, the surface horizon had the highest pH values and these values generally decreased with increasing soil depth. The soil's electrical conductivity (EC) was low (12 – 44 μS/cm), and the soil salinity ranged from 6% to 30%. The organic carbon (OC) content of the soils ranged from low (0.63%) to very high (3.03 %) and decreased down the profile in all the profiles. The total nitrogen (TN) content of the soils ranged very low (0.02%) to medium (0.26%). The available phosphorus (P) of the soils ranged from very low (0.83 mgkg) to medium (8.75 mg/kg) with a mean value of 3.11 mg/kg, and decreased with depth. The exchange site of the soils was dominated by calcium (Ca), magnesium (Mg), and sodium (Na) while potassium (K) had values lower than them. The values were 0.45 – 3.57 cmol/kg, 0.38 – 1.07 cmol/kg, 0.38 – 0.67 cmol/kg, and 0.04 – 0.20 cmol/kg for Ca, Mg, Na, and K respectively. The mean profile exchangeable acidity (EA) ranged from 0.04 cmol/kg to 0.08 cmol/kg and it was observed that the EA of the soils was irregularly distributed in all profiles. However, the effective cation exchangeable capacity (ECEC) of the soils ranged from very low to low and had values that ranged from 1.51 cmol/kg to 4.96 cmol/kg in all the assessed profiles. The statistical analysis showed a significant difference $p \leq 0.05$ in the ECEC contents of the profiles. In addition, the base saturation (BS) of the soils was high being greater than 50% and its value ranged from 95.51% to 99.11% with a mean value of 97.64%.

Suitability Classes for Watermelon Cultivation

The actual and potential of the climatic/land characteristics in determining the suitability of the soils for watermelon cultivation were evaluated using the parametric methods (Table 3). The climatic conditions of the study area are rated as S2 and S12 in terms of rainfall, temperature, and relative humidity (Table 4). This is because the mean annual rainfall in the range of 500-700 mm is considered to be relatively adequate. The slope, drainage, and flooding conditions were rated as S11. The average soil rooting depth in profiles was greater than 100 cm and was rated S11. The textural classes of the soils which include loamy sand in the surface horizons to sandy clay loam, and sandy clay in the subsurface horizons were rated as S12 for all the profiles. In terms of gravel contents, all the profiles were rated as S11. Apart from the base saturation and organic carbon which were high and rated as S11 and S12, all the other fertility requirements were sub-optimal and were rated between S2 and S3. The most limiting fertility parameter was the CEC which was rated as S3 in all the profiles.

Cumulatively, the aggregate actual suitability class of all the profiles by the Storie parametric model was S3 (41.7-48.5), while the square root model was also S3 (43.8-52.6), suggesting that the soils were currently marginally suitable for watermelon cultivation (Table 5). The potential suitability, which is a reflection of what is expected after good soil fertility management, was moderate (S2) as computed by the two models (Storie (80.8) and square root (82.8) models). This is an indication that the soils are potentially moderately suitable for watermelon cultivation. Thus, the fertility

Table 1: Morphological and Physical Characteristics of the Soils

Horizon designation	Depth (cm)	Colour matrix	Textural class	Structure	Consistency	Horizon boundary	Root	Sand	Silt	Clay	BD (g/cm3)	Ksat. (cm/hr)	Porosity (%)
Mapping Unit One (Profile 1)													
Ap	0-18	10YR4/3, db	LS	w, me, gr	ns, lo	sm, cl	me, c	864	16	120	1.18	2.94	43.65
Be	18-42	10YR5/3, b	LS	m, co, sab	ns, fr	sm, cl	f, c	844	26	130	1.23	1.58	45.42
Bt1	42-70	5YR4/4, rb	SL	m, me, sab	ss, fr	sm, cl	f, fe	774	46	180	1.29	1.49	47.68
Bt2	70-146	7.5YR5/6, sb	SCL	m, co, sab	ss, fr	-	f, fe	714	66	220	1.33	1.21	49.06
Mapping Unit Two (Profile 2)													
Ap	0-16	10YR3/2, vdgb	LS	w, f, cr	ns, lo	sm, cl	co, m	854	36	110	1.17	1.97	43.28
AB	16-62	10YR3/3, b	LS	m, me, sab	ns, fr	sm, cl	me, c	844	26	130	1.22	1.47	44.91
Bt	62-118	5YR4/4, rb	SL	m, me, sab	ss, fr	sm, cl	f, fe	774	86	140	1.34	1.04	4969
Br	118-150	5YR5/3, rb	SL	m, me, sab	ss, f	-	vf, f	734	66	200	1.36	0.89	50.2
Mapping Unit Three (Profile 3)													
Ap	0-25	10YR5/2, gb	LS	w, me, cr	ns, lo	sm, cl	co, c	834	36	130	1.27	1.63	47.05
Bt1	25-80	5YR4/8, yr	SCL	w, me, sab	ss, fr	sm, cl	f, fe	614	86	300	1.39	1.08	51.33
Bt2	80-130	5YR5/4, yb	SC	m, me, sab	s, f	-	vf, fe	594	46	360	1.42	0.67	52.58
	Mean							767.64	48.73	183.64	1.29	1.45	47.71
	SEM							16.13	4.23	13.86	0.01	0.1	0.53
	SD							92.66	24.27	79.64	0.08	0.6	3.06

Colour: db = dark brown, vdgb = very dark greyish brown, gb = grayish brown, rb = redish brown, b = brown, yr = yellowish red, yb = yellowish brown. Textural Class (TC): SL = Sandy loam, SCL = Sandy clay loam, SC = Sandy clay. Structure: w = weak, m = moderate, s = strong, f = fine, me = medium, co = coarse, cr = crumb, gr = granular, sab = sub-angular blocky. Consistency: ns = non-sticky, ss = slightly sticky, s = sticky, lo = loose, f = firm, fr = friable, so = soft. Horizons Boundary: sm = smooth, wv = wavy, ir = irregular, ab = abrupt, cl = clear, di = diffuse. Roots: vf = very fine, f = fine, me = medium, co = coarse (size), fe = few, c = common, m = many (concentration). BD = Bulk density

Table 2: Chemical Characteristics of the Soils

Horizon designation	Depth (cm)	pH (H_2O)	pH (KCl)	EC (µS/cm)	Salinity	OC (%)	TN (%)	Avail-P (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	Na (mg/kg)	K (mg/kg)	Al+H	ECEC	BS (%)
Mapping Unit One (Profile 1)															
Ap	0-18	6.68	5.05	40	30	2.34	0.15	8.75	3.57	0.53	0.67	0.07	0.04	4.88	99.11
Be	18-42	6.5	4.98	20	10	2.2	0.11	7.8	1.97	0.47	0.41	0.06	0.04	2.95	98.65
Bt1	42-70	6.51	4.9	20	11	1.93	0.08	4.12	2.13	0.44	0.43	0.06	0.05	3.11	98.39
Bt2	70-146	6.41	4.67	20	10	1.13	0.04	1.75	0.63	0.34	0.43	0.09	0.07	1.56	95.51
Mapping Unit Two (Profile 2)															
Ap	0-16	6.06	4.48	28	14	3.03	0.26	2.23	2.55	0.45	0.38	0.07	0.07	3.52	98.01
AB	16-62	5.81	4.43	39	20	2.46	0.15	2.1	1.82	0.55	0.45	0.08	0.06	2.96	97.98
Bt	62-118	5.79	4.3	16	8	1.6	0.07	1.55	2.26	1.07	0.41	0.12	0.08	3.94	98.05
Br	118-150	5.6	3.68	73	36	0.87	0.03	0.76	0.89	0.38	0.43	0.08	0.08	1.86	95.68
Mapping Unit Three (Profile 3)															
Ap	0-25	6.3	4 84	41	21	2.66	0.18	2.29	4.05	0.4	0.41	0.05	0.06	4.96	98.79
Bt1	25-80	6.11	4.45	44	22	1.36	0.06	2.04	1.93	1.07	0.43	0.2	0.08	3.71	97.84
Bt2	80-130	5.62	4.44	12	6	0.63	0.02	0.83	0.45	0.46	0.5	0.04	0.06	1.51	96.04
	Mean	6.13	4.56	27.7	14.85	1.84	0.11	3.11	2.02	0.56	0.45	0.08	0.06	3.18	97.64
	SEM	0.06	0.07	1.92	1.49	0.13	0.01	0.46	0.19	0.04	0.01	0.008	0.01	0.2	0.24
	SD	0.34	0.38	11.04	8.54	0.75	0.02	2.62	1.09	0.25	0.08	0.05	0.02	1.16	1.38

OC = Organic Carbon; TN = Total Nitrogen; Avail-P = Available Phosphorus, BS = Base Saturation; SEM = Standard Error of Mean; SD = Standard Deviation.

Table 3: Land/Soil Requirements for Suitability Evaluation of Watermelon

Land Qualities	S11 96-100	S12 86-95	S2 61-85	S3 41-60	N1 21-40	N2 0-20
Climate (C)						
Annual Rainfall (mm)	550-600	600-700	700-1000	>1000	-	-
Mean Temperature (°C)	26-28	28-30	30-32	32-35	-	>35
Relative Humidity (%)	45-60	60-80	80-90	>90	-	-
Topography (T)						
Slope Gradient (%)	0-4	4-8	8-16	16-30	30-50	>50
Wetness (W)						
Drainage	Wd	md	Id	Pd	pd	Vpd
Flooding	F0	F0	F0	F1	F1	F2
Soil Physical Properties (S)						
Soil Depth (cm)	>150	150-100	100-75	75-50	<50	<50
Surface Texture	SL, L, SiCL	LS, SCL, SC	S, LS, SiC	C>60S	-	C
Gravel at 0-20 cm (%)	0-3	3-15	15-35	35-55	-	>55
Fertility (F)						
pH in distilled water	6.5-6.0	6.0-5.8	5.8-5.5	5.5-5.0	<5.0	-
Organic Matter (%)	>2	2-12	1.2-0.8	<0.8	-	-
Total Ex. Cations (cmol/kg)	>5	5-3.5	3.5-2	<2	-	-
CEC (cmol/kg)	>24	24-16	<16(-)	<16(+)	-	-
Base Saturation (%)	>50	50-35	35-20	<20	-	-
Salinity and Alkalinity (N)						
ECe (dS/m)	0-3	3-4	4-6	6-8	-	>10
ESP (%)	0-8	8-15	15-20	20-25	-	>25

S11 (96-100) - No limitation; S12 (86-95) - Slight limitation; S2 (61-85) - Moderate limitation; S3 (41-60) - Severe limitation; N1 (20-40) - Very severe limitation that can be corrected; N2(0-19) - Very severe limitation that cannot be corrected. **Source**: Modified from Sys *et al.*, 1993

Table 5: Suitability Classes for Watermelon Cultivation

Land Qualities	Profile 1	Profile 2	Profile 3
Climate (C)			
Annual Rainfall (mm)	85(S2)	85(S2)	85(S2)
Mean Temperature (°C)	95(S12)	95(S12)	95(S12)
Relative Humidity (%)	95(S12)	95(S12)	95(S12)
Topography (T)			
Slope Gradient (%)	100(S11)	100(S11)	100(S11)
Wetness (W)			
Drainage	100(S11)	100(S11)	100(S11)
Flooding	100(S11)	100(S11)	100(S11)
Soil Physical Properties (S)			
Soil Depth (cm)	100(S11)	100(S11)	100(S11)
Surface Texture	95(S12)	95(S12)	95(S12)
Gravel at 0-20 cm (%)	100(S11)	100(S11)	100(S11)
Fertility (F)			
pH in distilled water	100(S11)	95(S12)	95(S12)
Organic Matter (%)	95(S12)	95(S12)	95(S12)
Total Ex. Cations (cmol/kg)	85(S2)	80(S2)	75(S2)
Cation Exchange Capacity (cmol/kg)	60(S3)	55(S3)	50(S3)
Base Saturation (%)	100(S11)	100(S11)	100(S11)
Salinity and Alkalinity (N)			
ECe (dS/m)	100(S11)	100(S11)	100(S11)
ESP (%)	100(S11)	100(S11)	100(S11)
Actual Suitability (Storie)	48.5(S3)	44.4(S3)	41.7(S3)
Actual Suitability (Square root)	52.6(S3)	48.2(S3)	43.8(S3)
Potential Suitability (Storie)	80.8(S2)	80.8(S2)	80.8(S2)
Potential Suitability (Square root)	82.8(S2)	82.8(S2)	82.8(S2)

S1 - highly suitable, S2 - moderately suitable, S3 - marginally suitable; N1 - currently not suitable; N2 - permanently not suitabl status of these soils needs an amendment to improve the productive capacity of the soils to those that are highly suitable for watermelon cultivation.

DISCUSSION

Considerable progress has been made in the assessment of soil potential for various crop production (Osinuga *et al.*, 2020). Soil suitability assessment based on an effective model is the first step for managing soil suitability. Different approaches and procedures for the potential of soil have been developed and implemented around the world. Soil colour is the function of chemical and mineralogical composition as well as the textural make-up of soil and is conditioned by topographic position and moisture regime (Singh *et al.*, 2013; Osinuga *et al.*, 2020). The blocky structures, that is, angular and sub-angular blocky, especially in subsoils, were due to the presence of higher clay fractions (Sharma *et al.*, 2004). Evidence of loose, friable and non-sticky and non-plastic or slightly sticky and slightly plastic consistency is attributed to the low amount of expanding clay minerals (Thangasamy *et al.*, 2004). The maximum accumulation of clay was found in the lower layers compared to the surface layers. This may be due to in situ weathering and translocation of clays to deeper layers along with percolating water. These results conform to earlier observations made by Reddy *et al.* (2005).

The soil reaction decreased with depth. The decrease in pH in the lower layers may be attributed to the loss of exchangeable bases. All the profiles exhibited very low to low electrical conductivity, indicating the non-saline nature of the soil. The low electrical conductivity may result from free drainage conditions that favour the leaching of released bases with percolating water (Singh *et al.*, 2013). The organic carbon content was low and diminished with depth because of the tropical climate, which facilitates rapid mineralisation at the surface. The surface samples recorded high organic carbon content due to the continuous addition of organic manure, alongside roots buried during cultivation practices. All profile samples indicated low nitrogen content, likely due to rapid mineralisation leading to leaching losses (Sehgal, 2008). The surface soils showing higher P may be attributed to the concentration of crop cultivation in the rhizosphere and the supplementation of depleted phosphorus through external fertiliser sources, as well as the fixation of more phosphorus in subsurface layers.

The dominance of exchangeable cations followed the order: $Ca^{2+} > Mg^{2+} > Na^{+} > K^{+}$. The same order was reported by Ajiboye *et al.* (2011) and Osinuga *et al.* (2020) in soils nearby. This could be attributed to more intense weathering, release of labile potassium from organic residues, application of potassium fertilisers and upward translocation of potassium from lower depths along with the capillary rise of groundwater (Leelavathi *et al.*, 2009). Low effective cation exchange capacity (ECEC) in these soils was due to the mixed type of kaolinitic, illitic, and other clay types. The ECEC fluctuates with an increase in the depth of all the profiles, which is attributed to an increase in clay content at lower depths.

Watermelon requires a well-distributed rainfall of around 400-600 mm during its growing season for optimal growth (Mayo *et al.*, 2016). The annual rainfall of the study area (1000-1500 mm) falls into the moderately suitable (S2) category across all profiles, indicating that planting of watermelon should be done at the onset of the rainy season or late season. Excessive rainfall can lead to the abortion of flowers and the rapid deterioration of the fruits. The mean temperatures (24°C - 35°C) of the area are perfect for watermelon, with optimal growth at around 24°C to 30°C (Huh *et al.*, 2019). A slope gradient rating of 100 (S11) indicates highly suitable conditions, suggesting that the land's topography is ideal for watermelon cultivation. Gentle slopes facilitate effective drainage, reducing the risk of waterlogging and soil erosion (Singh *et al.*, 2018). The drainage of the soil is highly suitable for watermelon. Watermelon requires well-drained soils to prevent root diseases and other water-related stress factors (Karim *et al.*, 2017). Watermelon plants have deep root systems, and sufficient soil depth is critical for root penetration and access to nutrients and water (Miller *et al.*, 2019). The highly suitable ratings for soil depth and minimal gravel content indicate that the soil provides an adequate rooting zone, promoting robust plant growth. A loamy texture is preferred for watermelon as it balances water retention and drainage. The surface texture rating of 95 (S12) suggests that the soil texture is highly suitable, providing an optimal environment for root development and nutrient uptake (Lal *et al.*, 2017).

Watermelon thrives in slightly acidic to neutral soils with a pH range of 6.0 to 7.5 (Brady and Weil, 2016). The pH ratings indicate highly suitable conditions across all profiles, ensuring that nutrient availability and microbial activity in the soil are conducive to watermelon growth. Organic matter enhances soil structure, water-holding capacity, and nutrient availability. The current organic matter content can still support the healthy growth and development of watermelon. Moderately suitable ratings for total exchangeable cations suggest that while the soil has a reasonable nutrient supply capacity, some supplementation with fertilisers might be needed to meet the crop's nutritional requirements. The marginally suitable ratings for cation exchange capacity (CEC) indicate a limitation in the soil's ability to retain and supply essential nutrients. This could necessitate frequent nutrient applications to maintain adequate fertility levels for watermelon (Havlin *et al.*, 2016). High base saturation indicates a well-balanced soil cation composition, essential for plant health and growth. The highly suitable rating (S11) across all profiles confirms optimal conditions for nutrient availability (Mengel and Kirkby, 2012). Watermelon is sensitive to salinity, and both electrical conductivity (ECe) and exchangeable sodium percentage (ESP) ratings are highly suitable (S11), indicating that salinity and sodicity are not limiting factors. This ensures that the soil environment supports healthy plant growth without the risk of salt stress (Bernstein, 2014; Mathewos *et al.*, 2018).

CONCLUSIONS

The soil suitability assessment conducted for watermelon cultivation at CEADESE Farms, Federal University of Agriculture, Abeokuta, highlights the critical influence of various soil parameters on crop productivity. Utilising a parametric model provided a comprehensive analysis of the soil's physical and chemical properties, enabling a detailed classification of soil suitability. The study identified that the soils in the study area exhibit a suitability class of marginally suitable (S3), indicating severe limitations. Key factors such as soil texture, organic matter content, cation exchange capacity, and base saturation were crucial in determining the suitability levels. The potential suitability revealed that the soils were moderately suitable (S2) for watermelon cultivation. This improvement underscores the model's efficacy in predicting and enhancing soil suitability for optimal agricultural outcomes in the cultivation of watermelons. Furthermore, the analysis of soil suitability for watermelon production across the three profiles reveals a generally favourable environment with high suitability in climate, topography, wetness, and several soil physical properties. However, soil fertility parameters, particularly CEC, present limitations that classify the current suitability as marginal (S3). With targeted soil management practices, these soils have the potential to support watermelon cultivation maximally.

REFERENCES

Aiboni V. U. 2001. Characteristics and classification of soils of a representative topography location in UNAAB. *ASSET Series A* 1(1): 35-50

Ajiboye, G. A., Alabi, K. O., Adesodun, J. K. and Aiboni, V. U. 2011. Classification and suitability evaluation of the soils of a toposequence at Odeda, Ogun State for the production of rice (Oryza sativa). *Nigerian Journal of Soil Science* 21(2): 142-155.

Brady, N. C. and Weil, R. R. 2008. The nature and properties of soils. Pearson Education.

Gee G. and Bauder J. W. 1986. Particle size analysis. In: Klute A. (eds.). Methods of Soil Analysis. Madison WI: *American Society of Agronomy*, 1: 91-100.

Havlin, J. L., Tisdale, S. L., Nelson, W. L. and Beaton, J. D. 2016. Soil fertility and fertilizers: An introduction to nutrient management. Pearson.

Huh, K. H., Kim, D. S. and Lee, S. H. 2019. Optimal temperature for watermelon growth. *Journal of Horticultural Science* 54(2): 179-188.

Lal, R. 2015. Soil conservation: Techniques and practices for sustainable land use.

Leelavathi, G. P., Naidu, M. V. S., Ramavatharam, N. and Sagar, G. K. 2009. Studies on genesis, classification and evaluation of soils for sustainable land use planning in Yerpedu Mandai of Chittoor District, Andhra Pradesh. *Journal of the Indian Society of Soil Science 57*(2): 109–120.

Mathewos, M., Dananto, M., Erkossa, T. and Mulugeta, G. 2018. Parametric land suitability assessment for rainfed agriculture: the case of Bilate Alaba Sub-watershed, Southern Ethiopia. *Agrotechnology* 7:183.

Mayo, J., Smith, J. and Harris, M. 2016. Watermelon production and yield under varying rainfall conditions. *Agricultural Water Management* 174: 64-72.

Mengel, K. and Kirkby, E. A. 2012. Principles of plant nutrition. 5th Edition, Springer, Dordrecht.

Miller, W. P., Murphy, L. M. and Zink. M. F. 2019. Root systems and soil depth. *Soil Science Society of America Journal* 83(3): 350-360.

Murphy, J. and Riley, J. P. 1962. A modified single solution method for the determination of phosphate in natural waters. *Analytica Chimica Acta* 27: 31-36.

Nelson, D. W. and Sommers, L. E. 1996. Total carbon, organic carbon and organic matter. In D. L. Sparks (Eds.) Methods of Soil Analysis. Part 3. Chemical methods. SSSA Book Ser. 5. SSSA, Madison, WI, pp. 961-1010.

Osinuga O. A., Aiboni V. U. and Oyegoke C. O. 2020. Classification and suitability evaluation of soils along a toposequence for rice production in Alabata, southwest Nigeria. *Agro-Science* 19(4): 43-50.

Page, A. L., Miller, R. H. and Keeney, D. R. 1982. Methods of soil analysis. (Eds) Agronomy 9, part 2, ASA, Madison Wisconsin.

Reddy, R. S., Naidu, S. L., Ramesh Kumar, L. G. K., Budhilal, S. C. and Krishnan, P. 2005. Land resources of Medak District, Andhra Pradesh, NBSS Publ., NBSS and LUP, Nagpur. 791pp.

Saaty, T. L. 1980. The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation. McGraw-Hill.

Sehgal, J. 2008. Pedology-concepts and applications. Second Revised and Expanded Edition, Kalyani Publishers, New Delhi.

Shah, F. and Wu, W. 2019. Soil and crop management strategies to ensure higher crop productivity within sustainable environments. *Sustainability* 11: 1485.

Sharma, S. S., Totawat, K. L. and Shyampura, R. L. 2004. Characterization and classification of salt affected soils of Southern Rajasthan. *Journal of Indian Society of Soil Science* 52: 209-213.

Singh, T. B., Devi, K. D., Kumar, Y. B., Bishworjit, N., Singh, L. N. K. and Singh, A. H. 2013. Characterization and evaluation for crop suitability in lateritic soils. *African Journal of Agricultural Research* 8(37): 4628-463.

Storie, R. E. 1978. Storie index soil rating Oakland: Division of Agriculture Sciences, University of California, Special Publication 3203.

Sys C., Ranst V., Debaveye J. and Beernaert F. 1993. Land evaluation Part III, crop requirements. Agricultural Publication No. 7, ITC, Ghent.

Thangasamy, A., Naidu, M. V. S. and Ramavatharam, N. 2004. Clay mineralogy of soils in the Sivagiri micro-watershed of Chittoor district, Andhra Pradesh. *Journal of Indian Society of Soil Science* 52: 454-461.

Thomas, G. W. 1982. Exchangeable cations. In Page, A. L., Miller, A. and Keeney, D. R. (eds.). Methods of Soil Analysis Part 2. Agronomy Monograph 9 (2nd ed.), ASA and SSSA, Madison, Wiscosin, USA, pp 159 -165

Udo, E. J., Ibia, T. O., Ogunwale, J. A., Ano, A. O. and Esu, I. E. 2009. Manual of soil, plant and water analysis. Lagos, Nigeria: Sibon Books Ltd. 183pp.

Influence of different control strategies on incidence, abundance and severity of fall armyworm on maize

Rosulu, H. O., Adanlawo, A. O., Lawal, A. O. and Musa, S. O.
Crop Production Technology Department,
School of Agricultural Technology, Yaba College of Technology, Epe Campus. Yaba, Lagos, Nigeria.

ABSTRACT

To prevent the loss of maize on the field, a study was conducted at the Yaba College of Technology Teaching and Research Farm in the 2023 wet season, to determine the influence of different control strategies on the incidence, abundance and severity of Fall armyworm (*Spodoptera frugiperda* S.) on Maize (*Zea mays*). There were 6 treatments with 3 replications laid out in a Randomized Complete Block Design (RCBD). Data were collected on growth parameters at 2, 4, 6 and 8 weeks after planting. Pest population before and after spraying, yield parameters, cob damage and phytotoxicity signs. Data collected were subjected to Two-way analysis of variance. Black pepper (*Piper nigrum*) aqueous extract recorded the highest number of leaves (10.00 ± 0.54), followed by Probiotics, Sweet potato, Sodium hydrogen carbonate and synthetic insecticides (10.00 ± 0.54) compared to untreated plots (9.67 ± 0.54) in terms of cob damage and cob yields (0.22 ± 0.05). Sodium hydrogen carbonate has a higher phytotoxicity sign (11.67 ± 3.83) than other treatments, although suppresses pest populations (0.00 ± 0.00) when compared to untreated plots (20.67 ± 3.83). Therefore, the use of bio-control options such as extract of plants helps to control pests of crops. It is therefore recommended that farmers should adopt the use of plant botanicals, especially Black Pepper (*P. nigrum*) aqueous extract for the control of Fall armyworm on Maize for optimum production and performance in yield of Maize.

Key words: fall armyworm, maize, pest, plant botanicals

***Corresponding author**: hamed.rosulu@yabatech.edu.ng

INTRODUCTION

Maize (*Zea mays* L.), a member of the Poaceae family, ranks among the world's most widely cultivated cereal crops due to its versatile applications in human nutrition, livestock feed, biofuel production, and industrial uses (Abebe and Feyisa, 2017). This adaptable crop thrives across diverse agroecological zones, including temperate, tropical, and subtropical regions (Ranum *et al.,* 2014). According to IITA (2018), global maize consumption exceeds 116 million tons annually, with Africa accounting for approximately 30% of this total. In Nigeria and other African nations, maize serves as both a dietary staple and an economic mainstay for smallholder farmers (IITA, 2020). Despite its agricultural significance, maize production faces substantial challenges from abiotic stresses like drought and heat (Cairns *et al.,* 2013), as well as biotic threats including the invasive Fall Armyworm (*Spodoptera frugiperda*) (CIMMYT, 2019; IITA, 2019).

The polyphagous Fall Armyworm (FAW), originating from tropical America, represents a severe threat to cereal crops, particularly maize (Capinera, 2017). Its larval stage causes extensive damage through foliar consumption, tassel destruction, and ear feeding, potentially reducing yields by up to 40% (Chimweta *et al.,* 2020). FAW's broad host range encompasses over 100 plant species, including critical staples like sorghum, rice, and millet (Montezano *et al.,* 2018).

This study investigates alternative pest management strategies using botanical extracts from underutilized plants with demonstrated pesticidal properties. Sweet potato (*Ipomoea batatas* L.), containing bioactive compounds such as flavonoids, alkaloids, and phenols (Harrison *et al.,* 2003), and black pepper (*Piper nigrum* L.), rich in insecticidal alkaloids (Awoyinka *et al.,* 2006), represent promising candidates. These locally available crops offer sustainable alternatives to synthetic pesticides while addressing concerns about pest resistance and environmental impact.

The research evaluates these plant-derived solutions alongside microbial agents like *Bacillus thuringiensis* (Byjus, 2023) to develop integrated pest management strategies against FAW in maize production systems. By leveraging these underutilized biological resources, this work contributes to sustainable agriculture while addressing food security challenges in smallholder farming communities.

MATERIALS AND METHODS

Experimental site:

The research trial was carried out during the 2023 wet season at Yaba College of Technology's Teaching and Research Farm, Epe Campus (Odoragushin, Lagos State). Complete soil analyses (pre-trial and post-harvest) was carried out to assess chemical properties and nutrient dynamics of the soil (Table 1).

The maize seeds used for the experiment were of the Oba Super variety, procured from a certified agricultural input supplier. Plant materials consisted of sweet potato leaves collected from Yaba College of Technology's Epe Campus and surrounding areas, along with black pepper seeds purchased from local markets in Epe. For probiotic preparation, a mixture of rice, water, milk and molasses was used. The sodium hydrogen carbonate ($NaHCO^-$) solution was formulated by combining $NaHCO^-$ with neem oil, liquid soap and water. As a standard chemical control, Cypermethrin insecticide was obtained from a reputable agrochemical dealer. Additionally, a pre-emergence herbicide (Paraquat) application was implemented prior to seed sowing for effective weed management.

Preparation of botanicals

Botanicals:

Dried black pepper fruits and sweet potato leaves were blended into paste. For each extract, 20 g of paste was soaked in 750ml water for 24 hours with periodic stirring. After filtration, extracts were applied as foliar sprays between 10:00 am-12:00 noon using knapsack sprayers, with reapplication following rainfall within 2 hours of spraying (Opareke *et al.,* 2005).

Organic Pesticide:

The organic pesticide formulation consisted of sodium hydrogen carbonate (2 teaspoons (28 g) dissolved in 1000 ml of water), combined with biodegradable liquid soap (1 tablespoon (10 ml)) and neem oil (2 tablespoons (5 ml)). The mixture was thoroughly stirred for two minutes and left to settle for 3–4 minutes before application.

Probiotics:

Rice (150 g) was rinsed with 750ml water until the rinse water turned opaque. After 3-days fermentation, 375ml rice water was mixed with 300ml milk and fermented for 7 days. For application, 100ml of this mixture was combined with 100ml molasses, diluted with 1800ml water, and matured for 1 week before spraying (Gupta *et al.*, 2010).

Phytochemical analysis of extracts:

Following Association of Analytical Chemists (AOAC, 2002) methods modified by Ekeh *et al.* (2013), extracts were processed to quantify alkaloids, saponins, reducing sugars, steroids, and terpenoids, with residues stored at 5°C in sterile containers.

Experimental protocol:

Land preparation followed established agronomic practices by Rosulu *et al.,* (2022), beginning with complete vegetation clearance, stump removal, and debris disposal. The field underwent sequential tillage operations including ploughing, harrowing, and ridge formation to optimize seedbed conditions. The experimental layout consisted of 18 plots (5 m × 6.75 m each), with five ridges per plot spaced at 0.7m intervals. Buffer zones of 1.5m separated all plots and blocks, yielding a total experimental area of 303.75 m². Maize was planted at 60cm spacing with two seeds per hole, later thinned to one seedling per stand.

The study implemented a randomized complete block design with six treatments replicated three times as follows: T_1 - Control, T_2 - Synthetic Insecticide, T_3 - Sweet potato leaf extract, T_4 - Black pepper seed extract, T_5 - Probiotics, T_6 - Sodium Hydrogen Carbonate ($NaHCO_3$)

Data collection:

Data on maize were collected based on the following parameters:

i. **Growth parameters of maize at 2, 4, 6 and 8 weeks after planting:** To evaluate maize development, growth parameters were monitored at 2, 4, 6, and 8 weeks after planting (WAP). For each plot, 20 representative plants were randomly selected and tagged for consistent measurement. Plant height was determined by measuring from the soil surface to the apical bud using a tape measure in centimeter (cm). Leaf counts were obtained through direct visual observation at each assessment interval. Additionally, leaf area was measured in (cm) using a tape rule to quantify foliar development.

ii. **Pest population:** Insect population assessments were conducted during peak inactivity periods (6:30 am - 9:00 am) to maximize counting accuracy. Sampling occurred at two critical time points: 24 hours before pesticide application and 24 hours post-application. Following established methodologies (Okunlola *et al.,* 2008; Rosulu *et al.*, 2022), pest incidence was quantified through direct visual counts using the standardized Tilton formula for maize systems.

$$\text{Efficacy (\%)} = 1 - [\frac{T_a}{C_a} \times \frac{sC_b}{T_b}] \text{ x } 100$$

where: T_a = Infestation in the treated plot after application; C_a = Infestation in the check plot after application; T_b = Infestation in the treated plot before application; sC_b=Infestation in the check plot before application

iii. **Cob density:** A measure of the efficacy of insecticide against fall armyworm infestation on maize was accessed at 8 weeks after spraying by counting cobs produced from a random sample of 20 plants per plot.

iv. **Cob damage:** Damage severity was quantified through systematic assessment of four morphological indicators: shriveling, twisting, stunting, and constriction. For each plot, 20 randomly selected plants were evaluated by recording damaged cobs per plant. The damage percentage was calculated using the formula described by Rosulu *et al.,* (2022):

$$Cob\ damage = \frac{Number\ of\ damaged\ cobs}{Total\ cobs/plant}\ x\ 100$$

v. **Cob Yield:** At harvest maturity, total cob yield was recorded from each experimental plot. Following established protocols (Rehaja, 1976; Rosulu *et al.,* 2022), raw yield measurements were converted to kilograms per hectare (kg/ha) using the formula:

$$Yield\ \left(\frac{kg}{ha}\right) = \frac{a\ x\ 10{,}000}{b\ x\ 10{,}000}$$

Where: a = plot yield; b = net plot size

vi. **Assessment of phytotoxicity:** Phytotoxicity symptoms (discoloration/ burning/wilting/bud stunting) were evaluated on 20 random plants per plot 2 days post-spraying.

Data analysis

All experimental data were collected in triplicate and analyzed using two-way analysis of variance (ANOVA) in MINITAB 17 statistical software. Treatment means were compared using Tukey's Honestly Significant Difference (HSD) test at a 95% confidence level (α = 0.05) to determine significant differences between groups.

RESULTS

Soil physicochemical properties before and after planting:

The pre- and post-experiment soil characteristics are presented in Table 1. Initial analysis revealed slightly acidic conditions (pH 6.25), which remained consistent after cultivation (pH 6.42). The soil maintained a sandy loam texture throughout the study period, characterized by high sand content (>75%) and low silt and clay fractions (<25%), indicating limited water retention capacity during drought periods. Soil organic carbon content exceeded 1%, demonstrating moderate organic matter levels. Post-harvest analysis showed distinct nutrient dynamics: magnesium (Mg^{2+}) and calcium (Ca^{2+}) concentrations increased, while sodium (Na^{+}), nitrogen (N), phosphorus (P), and potassium (K^{+}) levels decreased. This nutrient depletion likely reflects maize uptake during growth and development.

Phytochemical Constituents of Plant Extracts:

Phytochemical analysis of the biopesticidal extracts revealed distinct compositional profiles (Table 2). The *Piper nigrum* extract contained moderate concentrations of reducing sugars (4.63), flavonoids (4.38), and its characteristic piperine alkaloid (9.36), along with minor quantities of saponins (2.08) and terpenoids (3.06). *Ipomoea batatas* extract similarly showed moderate levels of reducing sugars (10.4), terpenoids (6.3), and flavonoids (3.78), but only trace amounts of tannins (3.15). The probiotic formulation exhibited moderate reducing sugar content (11.32) with small amounts of saponins (6.34), tannins (0.02), and phenols (0.7). Notably, all three extracts completely lacked detectable alkaloids (except piperine in *P. nigrum*), glycosides, and steroids, suggesting shared metabolic limitations in these biochemical pathways. The consistent presence of flavonoids across plant-derived extracts and the unique piperine content in black pepper may contribute to their respective pesticidal activities.

Table 1: Soil physicochemical properties before and after planting

Parameters	Pre-planting	Post-planting
pH	6.25	6.42
Organic Carbon (%)	1.71	3.23
Particle Size (%)		
Sand (%)	72.3	78.23
Silt (%)	8.2	5.23
Clay (%)	19.5	16.54
Exchangeable bases		
Ca ($Cmolkg^{-1}$)	2.90	4.37
Mg ($Cmolkg^{-1}$)	1.74	1.90
Na ($Cmolkg^{-1}$)	1.59	0.99
K ($Cmolkg^{-1}$)	0.79	0.69
Acidity $A1^{+}+ H^{-1}$ ($Cmolkg^{-1}$)	0.10	0.09
C.E.C ($Cmolkg^{-1}$)	13.37	14.46
Base Saturation (%)	7.02	7.95
Macro-nutrient		
Total Nitrogen (%)	0.17	0.16
Mg ($Cmolkg^{-1}$)	1.74	1.90
Av. P ($MgKg^{-1}$)	9.56	8.75
Micronutrients		
Fe ($MgKg^{-1}$)	22.10	20.00
Cu ($MgKg^{-1}$)	4.30	4.70
Zn ($MgKg^{-1}$)	5.80	1.90
Mn ($MgKg^{-1}$)	28.7	33.3
Bulk Density	0.22	0.43
Textural class	Sandy Loam	Sandy loam

Table 2: Phytochemical constituents of plant extract

PARAMETERS	*Piper nigrum*		*Ipomea batatas*		Probiotics	
	Qualitative Indication	Quantitative Indication	Qualitative Indication	Quantitative Indication	Qualitative Indication	Quantitative Indication
Reducing Sugar (%)	++	4.63	++	10.4	++	11.32
Saponin (%)	+	2.08	-	0.00	+	6.34
Tannin (mg/100g)	-	0.00	+	3.15	+	0.02
Flavonoid (%)	++	4.38	++	3.78	-	0.00
Alkaloids (%)	-	0.00	-	0.00	-	0.00
Glycosides (mg/100g)	-	0.00	-	0.00	-	0.00
Terpenoids (%)	+	3.06	++	6.3	-	0.00
Phenol (mg/100g)	-	0.00	-	0.00	+	0.7
Steroids (%)	-	0.00	-	0.00	-	0.00
Piperine (mg/100g)	++	9.36	-	0.00	-	0.00

(++) = present in moderate quantity, (+) = present in small quantity, (-) = not present

Impact of treatments on number of leaves at 2, 4, 6 and 8 WAP

The influence of treatments on foliar development is presented in Table 3. Result revealed significant differences ($p \leq 0.05$) in leaf number at 4 WAP, where treatments T2, T5, and T6 had the highest number of leaves (7.67 ± 0.29), significantly outperforming T3 and T4 (7.00 ± 0.29). However, no significant treatment effects were observed at earlier (2 WAP) or later from 6 - 8 WAP. These results suggest that certain biopesticidal treatments may transiently enhance leaf production during active vegetative growth without sustained effects on later developmental stages.

Impact of treatments on plant height at 2, 4, 6 and 8 WAP

The results presented in Table 4 demonstrates the effects of different treatments on maize plant height at 2, 4, 6 and 8 weeks after planting (WAP). Data revealed variation ($p \leq 0.05$) in plant height among treatments at each growth stage. At 2 WAP, treatment T4 produced the tallest plants (51.57 ± 1.20 cm), while T3 produced the shortest plants (48.74 ± 1.20 cm). By 4 WAP, the height advantage shifted to T3 (120.69 ± 13.98 cm), with T4 showing the lowest values (88.26 ± 13.98 cm). At 6 WAP, treatment T6 achieved the maximum plant height (122.93 ± 5.57 cm), whereas T4 again showed minimal growth (105.75 ± 5.57 cm)

Table 3: Impact of treatments on number of leaves at 2, 4, 6 and 8 WAP

Treatments	Number of leaves			
	2 WAP	4 WAP	6 WAP	8 WA)
T_1	5.67 ± 0.33^{a}	7.33 ± 0.29^{ab}	8.33 ± 14.19^{a}	9.67 ± 0.54^{a}
T_2	6.00 ± 0.33^{a}	7.67 ± 0.29^{a}	8.33 ± 14.19^{a}	10.00 ± 0.54^{a}
T_3	5.67 ± 0.33^{a}	7.00 ± 0.29^{b}	8.33 ± 14.19^{a}	10.00 ± 0.54^{a}
T_4	6.00 ± 0.33^{a}	7.00 ± 0.29^{b}	8.67 ± 14.19^{a}	10.33 ± 0.54^{a}
T_5	6.00 ± 0.33^{a}	7.67 ± 0.29^{a}	8.67 ± 14.19^{a}	10.00 ± 0.54^{a}
T_6	5.67 ± 0.33^{a}	7.67 ± 0.29^{a}	8.33 ± 14.19^{a}	10.00 ± 0.54^{a}

Values represent least square means (LS-means) ± standard error. LS-means were separated using the Least Significant Difference and LS-means within a column followed by different letters are significantly different at $p \leq 0.05$. T1 = Control, T2 = Synthetic Insecticide, T3 = Sweet Potato leaf extract, T4 = Black pepper seed extract, T5 = Probiotic, T6 = Sodium hydrogen carbonate ($NaHCO_3$)

Table 4: Impact of treatments on plant height at 2, 4, 6 and 8 WAP

Treatments	Plant height (cm)			
	2 WAP	4 WAP	6 WAP	8 WAP
T_1	48.99±1.20^{ab}	95.92±13.98^{ab}	120.69±5.57^{a}	151.39±7.26^{a}
T_2	49.52±1.20^{ab}	99.93±13.98^{ab}	108.20±5.57^{b}	137.30±7.26^{a}
T_3	48.74±1.20^{b}	120.69±13.98^{a}	111.11±5.57^{ab}	140.55±7.26^{a}
T_4	51.57±1.20^{a}	88.26±13.98^{b}	105.75±5.57^{b}	144.55±7.26^{a}
T_5	50.00±1.20^{ab}	99.77±13.98^{ab}	113.79±5.57^{ab}	148.98±7.26^{a}
T_6	49.98±1.20^{ab}	105.47±13.98^{ab}	122.93±5.57^{a}	147.98±7.26^{a}

Values represent least square means (LS-means) ± standard error. LS-means were separated using the Least Significant Difference and LS-means within a column followed by different letters are significantly different at $p \leq 0.05$. T1 = Control, T2 = Synthetic Insecticide, T3 = Sweet Potato leaf extract, T4 = Black pepper seed extract, T5 = Probiotic, T6 = Sodium hydrogen carbonate ($NaHCO_3$)

while at 8 WAP, T1 recorded the highest plant height (151.39±7.26 cm) and T2 recorded the lowest plant height (137.30±7.26).

Impact of treatments on leaf area at 2, 4, 6 and 8 WAP

The analysis of leaf area progression in *Zea mays* under different treatments is presented in Table 5. Results showed no significant differences ($p > 0.05$) in leaf area among treatments from 6 to 8 weeks after planting (WAP). However, variations were observed, with treatment T4 consistently having the highest leaf area at both growth stages (370.58 ± 29.63 cm² at 6 WAP and 590.15 ± 48.57 cm² at 8 WAP). In contrast, T1 showed the lowest leaf area measurements at both evaluation periods (341.61 ± 29.63 cm² at 6 WAP and 502.49 ± 48.57 cm² at 8 WAP).

Impact of treatments on pest population dynamics

The evaluation of pest populations before and after treatment application is presented in Table 6. Initial assessments revealed no variation ($p > 0.05$) in pest numbers across plots prior to treatment implementation. However, post-application analysis demonstrated significant treatment effects ($p \leq 0.05$), with T5 showing the highest pre-treatment pest density (5.33 ± 2.06). Remarkably, all treatments (T1 - T6) achieved complete pest elimination (0.00 ± 0.00) following application, indicating 100% efficacy in pest suppression during the observation period.

Table 5: Impact of treatments on leaf area at 2, 4, 6 and 8 WAP

Treatment	Leaf area (cm^2)			
	2 WAP	4 WAP	6 WAP	8 WAP
T_1	131.39±6.24^{ab}	198.44±9.21^{ab}	341.61±29.63^{a}	91.55±48.57^{a}
T_2	125.82±6.24^{ab}	176.31±9.21^{c}	365.69±29.63^{a}	91.08±48.57^{a}
T_3	126.06±6.24^{ab}	207.48±9.21^{a}	347.63±29.63^{a}	93.88±48.57^{a}
T_4	137.27±6.24^{a}	203.82±9.21^{ab}	370.58±29.63^{a}	93.42±48.57^{a}
T_5	131.89±6.24^{ab}	177.23±9.21^{c}	361.66±29.63^{a}	92.05±48.57^{a}
T_6	119.18±6.24^{b}	186.61±9.21^{c}	345.66±29.63^{a}	88.85±48.57^{a}

Values represent least square means (LS-means) ± standard error. LS-means were separated using the Least Significant Difference and LS-means within a column followed by different letters are significantly different at $p \leq 0.05$. T1 = Control, T2 = Synthetic Insecticide, T3 = Sweet Potato leaf extract, T4 = Black pepper seed extract, T5 = Probiotic, T6 = Sodium hydrogen carbonate ($NaHCO_3$)

These results suggest that while initial pest distribution was homogeneous across the experimental area, the applied botanical interventions were uniformly effective in controlling the target pest population.

Table 6: Impact of treatments on pest population dynamics

Treatments	PPOBS	PPOAS
T_1	3.33 ± 2.06^a	0.00 ± 0.00^a
T_2	3.67 ± 2.06^a	0.00 ± 0.00^a
T_3	2.67 ± 2.06^a	0.00 ± 0.00^a
T_4	2.67 ± 2.06^a	0.00 ± 0.00^a
T_5	5.33 ± 2.06^a	0.00 ± 0.00^a
T_6	3.00 ± 2.06^a	0.00 ± 0.00^a

Values represent least square means (LS-means) ± standard error. LS-means were separated using the Least Significant Difference and LS-means within a column followed by different letters are significantly different at $p \leq 0.05$. T1 = Control, T2 = Synthetic Insecticide, T3 = Sweet Potato leaf extract, T4 = Black pepper seed extract, T5 = Probiotic, T6 = Sodium hydrogen carbonate ($NaHCO_3$), PPBOS = Pest population before spraying, PPOAS = Pest population after spraying

Phytotoxic Effects of Botanical Treatments on Maize Plants

The assessment of treatment-induced phytotoxicity symptoms is presented in Table 7. Reesult revealed significant differences ($p \leq 0.05$) in phytotoxic responses among treatments. Plants treated with sodium hydrogen carbonate ($NaHCO^-$, T6) exhibited the most severe phytotoxicity symptoms (20.67 ± 3.83), manifesting as visible leaf shrinkage. In contrast, treatments T1 through T5 showed reduced phytotoxic effects with T4 having the lowest phytotoxic symptom (10.33±3.83). These findings demonstrate that while most plant-derived treatments were non-phytotoxic, the $NaHCO^-$ based intervention caused measurable stress to maize plants, suggesting the need for concentration optimization in future applications.

Table 7: Phytotoxic effects of botanical treatments on maize plants

Treatments	Phytotoxicity shrivelling
T1	13.67±3.83a
T2	15.33±3.83ab
T3	10.33±3.83b
T4	11.33±3.83b
T5	20.67±3.83ab
T6	11.67±3.83b

Values represent least square means (LS-means) ± standard error. LS-means were separated using the Least Significant Difference and LS-means within a column followed by different letters are significantly different at $p \leq 0.05$. T1 = Control, T2 = Synthetic Insecticide, T3 = Sweet Potato leaf extract, T4 = Black pepper seed extract, T5 = Probiotic, T6 = Sodium hydrogen carbonate ($NaHCO_3$)

Treatment Effects on yield components of maize

The results presented in Table 8 demonstrate the effects of different treatments on yield parameters of *Zea mays,* including cob density, cob damage, and cob yield. Analysis revealed that T1 showed the highest cob damage (37.0 ± 5.53%), while T3 exhibited the lowest damage incidence (4.74 ± 5.53%). For cob yield, T2 produced the highest yield (0.39 ± 0.05 kg/plant), significantly outperforming T1 and T5 (0.15 ± 0.05 kg/plant). Cob density was greatest in T6 (12.33 ± 1.80 cobs/plant) and lowest in T1 (9.00 ± 1.80 cobs/plant). These findings indicate that while T1 promoted higher cob numbers, it also resulted in substantially greater damage, whereas T3 provided effective protection against cob damage. The superior yield performance of T2 suggests it may be the most promising treatment among those tested, though all treatments showed improvements over the control in reducing cob damage.

DISCUSSION

The pre-planting soil analysis revealed deficiencies in nitrogen, magnesium, and calcium which areessential nutrients for plant

Table 8: Treatment effects on yield components of maize

Treatment	Cob den	Cob dam (%)	Cob yield
T_1	9.00±1.80^{a}	37.0±5.53^{a}	0.15±0.05^{b}
T_2	12.00±1.80^{a}	13.3±5.53^{bc}	0.39±0.05^{a}
T_3	9.33±1.80^{a}	4.74±5.53^{c}	0.16±0.05^{b}
T_4	12.33±1.80^{a}	8.10±5.53^{c}	0.22±0.05^{b}
T_5	11.33±1.80^{a}	5.60±5.53^{c}	0.15±0.05^{b}
T_6	12.33±1.80^{a}	24.1±5.53^{b}	0.18±0.05^{b}

Values represent least square means (LS-means) ± standard error. LS-means were separated using the Least Significant Difference and LS-means within a column followed by different letters are significantly different at $p \leq 0.05$. T1 = Control, T2 = Synthetic Insecticide, T3 = Sweet Potato leaf extract, T4 = Black pepper seed extract, T5 = Probiotic, T6 = Sodium hydrogen carbonate (NaHCO3), COB DEN = Con density, COB DAM = Cob damage.

growth and cellular development (Cyers *et al.,* 2018). While potassium levels were adequate, the observed nutrient depletion likely resulted from leaching or erosion processes. Post-planting analysis showed increased phosphorus content and reduced acidity, suggesting treatment-mediated improvement in soil fertility. These changes created more favorable growing conditions, potentially contributing to the observed plant performance. Phytochemical characterization of the botanical treatments identified a diverse array of bioactive compounds with known pesticidal properties, including flavonoids, piperine, and terpenoids. The presence of these secondary metabolites in *Piper nigrum* and *Ipomoea batatas* extracts provides a biochemical basis for their observed efficacy, supporting earlier work by Rosulu *et al.,* (2022) on plant-derived pest control agents. Particularly noteworthy was the identification of piperine as the dominant alkaloid in black pepper extracts, a compound with well-documented insecticidal properties. These findings align with the reports of Kayidu *et al.,* (2018) regarding the agricultural applications of these plant species in pest management.

The vegetative growth parameters demonstrated clear treatment effects, with probiotic applications showing particular promise in promoting leaf production throughout the 8 -week observation period. This sustained foliar development likely resulted from the combined effects of improved nutrient availability and effective pest suppression, allowing for unimpaired photosynthetic activity. Similarly, *Piper nigrum* treatments produced the most significant leaf area expansion, suggesting that its bioactive components may have stimulated growth while simultaneously protecting against pest. These growth enhancements translated directly to yield improvements, with treated plants generally outperforming controls in both cob quantity and quality.

Pest population dynamics provided compelling evidence for the botanicals' effectiveness, with all treated plots achieving complete pest elimination following application. This universal efficacy suggests that while the specific active compounds varied between treatments, each contained sufficient concentrations of bioactive molecules to disrupt pest populations. The results corroborate the findings of Niemeyer *et al.,* (2020) regarding neem oil's effectiveness and expand upon the work of Sola *et al.,* (2014) by demonstrating similar potential in alternative plant species.

Yield analysis revealed important distinctions between treatments, with *Piper nigrum* emerging as particularly noteworthy for its balanced performance by delivering high cob density and yield while minimizing damage. The mechanism likely involves piperine's dual action as both a growth stimulant and potent insecticide, as described by Fan *et al.,* (2011). While sodium hydrogen carbonate treatments showed yield benefits, their associated phytotoxicity suggests the need for careful concentration optimization.

Across all parameters, the botanical treatments consistently outperformed controls, supporting Oparaeke *et al.* (2005) findings on plant extracts capacity to protect yield potential while avoiding synthetic chemical residues.

This study demonstrates that carefully selected botanical treatments can provide effective pest management while enhancing maize productivity. The results particularly highlight *Piper nigrum's* potential as a sustainable alternative to synthetic inputs, though the efficacy of other plant species suggests valuable opportunities for developing integrated, locally-sourced pest management strategies. These findings contribute to the growing body of evidence supporting ecological intensification approaches in cereal production systems.

CONCLUSION AND RECOMMENDATIONS

The Fall Armyworm (FAW) has emerged as a devastating invasive pest capable of adapting to diverse agroecological conditions worldwide, posing significant threats to maize production. While synthetic pesticides have been widely employed for FAW control, their effectiveness has been compromised by issues of misuse, pest resistance, and resurgence. This study demonstrates that biopesticides, particularly plant-derived formulations and probiotics, offer viable alternatives for sustainable FAW management. The findings establish that probiotics serve as an effective microbial insecticides, successfully controlling pest populations while minimizing phytotoxic effects and ultimately enhancing cob density and yield. Among the botanical treatments evaluated, *Piper nigrum* (black pepper) extract demonstrated superior efficacy in reducing FAW infestation and improving yield parameters, positioning it as a promising candidate for integrated pest management programs. The insecticidal properties of black pepper, primarily attributed to its piperine content, show particular potential as a natural alternative to conventional synthetic insecticides.

Based on the experimental outcomes, it is recommended that control strategies and policy interventions should prioritize protection during the seedling and vegetative growth stages, as these critical developmental phases are most vulnerable to FAW damage and subsequent yield losses. Also, while various synthetic pesticides have demonstrated efficacy against FAW, the results of this study strongly advocates for the adoption of plant-based alternatives such as *Piper nigrum* and *Ipomoea batatas* extracts, combined with probiotic applications, which provides effective pest control while enhancing grain yield.

REFERENCES

Abebe, Z. and Feyisa, H. 2017. Effects of Nitrogen Rates and Time of Application on Yield of Maize: Rainfall Variability Influenced Time of N Application.

Association of Analytical Chemists (AOAC), 2002. Official Method of Analysis (17th Edition). Association of Official Analytical Chemists, Maryland 1106pp.

Awoyinka, O. A., Oyewole, I. O., Amos, B. M. W. and Onasoga1, O. F. 2006. The comparative pesticidal activity of dichloromethane extracts of Piper nigrum against *Sitophilus zeamais* and *Callosobruchus maculates*. *African Journal of Biotechnology*. 5: 2446–2449

Byjus, … 2023. Role of Bacterium as Bio-control Agent. https://byjus.com/question-answer/which-of-the-following-is-a-microbial-insecticide-bacillus-polymixabacillus-subtilisbacillus-brevisbacillus-thuringiensis/ Accessed on 21st June 2023.

Cairns, J. E., Hellin, J., Sonder, K., Araus, J. L., MacRobert, J. F., Thierfelder, C. and Prasanna, B. M. 2013. Adapting maize production to climate change in sub-

Saharan Africa. *Food Security,* 5, 345–360. https://doi.org/10.1007/s12571-013-0256-x

Capinera, J. L. 2017. Fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Insecta: Lepidoptera: Noctuidae). http://edis.ifas.ufl.edu/in255.

Chimweta, M., Nyakudya, I. W., Jimu, L. and Bray, M. A. 2020. Fall armyworm [*Spodoptera frugiperda* (J.E. Smith)] damage in maize: management options for flood recession cropping smallholder farmers. *International Journal of Pest Management*, 66(2): 142–154.

CIMMYT, 2019. Stress-tolerant maize for Africa. Mexico, DF: CIMMYT. https://www.cimmyt.org/projects/stress-tolerant-maizefor-africa-stma/

Cyers, J. K., Barker, D. J., Johnston, R. H. and Steen, R. 2018. The role of phosphorus in soil fertility.

Ekeh, F. N., Onah, I. E., Atama, C. I., Ivoke, N. and Eyo, J. E. 2013. Effectiveness of botanical powders against *Callosobruchus maculatus* (Coleoptera: Bruchidae) in some stored leguminous grains under laboratory conditions. *African Journal of Biotechnology*, 12(12): 1387-1391.

Fan, L. S., R. Muhamad, D. O. and Rahmani, M. 2011. Insecticidal properties of *Piper nigrum* fruit extracts and essential oils against *Spodoptera litura*. *International Journal of Agriculture and Biology*, 13: 517–522

Gupta A. P. and Gupta, V. K. 2010. "Formulation of Probiotics" by Critical Reviews in Biotechnology.

Harrison, H. F., Peterson, J. K., Snook, M. E., Bohac, J. R. and Jackson, D. M. 2003. Quantity and potential biological activity of caffeic acid in sweet potato [*Ipomoea batatas* (L.) Lam.] Storage root periderm. *Journal of Agriculture and Food Chemistry.* 51: 2943–2948. doi: 10.1021/jf0211229

IITA (International Institute for Tropical Agriculture) 2019. Maize. Crops. Ibadan, Nigeria: IITA. https://www.iita.org/crops/maize/ Accessed 23/06/2023.

IITA, 2020. Guide to maize production in Northern Nigeria. www.iita.org. *FeedTheFuture*.

Kayidu, M. M., Mahungu, H. G., and Stark, A. F., 2018. "Piperine, a major alkaloid present in black pepper (*Piper nigrum*), exhibits potential as a fumigant and contact insecticide". *Journal of Stored Products Research*. 10 163- 173.

Montezano, D. G., Specht, A., Sosa-Gomez, D. R., Roque-Specht, V. F., Sousa-Silva, J. C., Paula-Moraes, S. V., Peterson, J. A. and Hunt, T. E. 2018. Host plants of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in the Americas. *African Entomology*. 26: 286–300.

Niemeyer, T., Madalena, E. and Borges, A. 2020. Effectiveness of neem oil for the control of fall armyworm *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) on maize. *Journal of Plant Protection Research,* 60(2): 315 - 324.

Okunlola, A. I., Ofuya, T. I. and Aladesanwa, R. D. 2008. Efficacy of plant extract on major insect pest of selected leave vegetables on South Westhern Nigeria. *Medwell Online Agricultural Journal,* 3(3): 181– 84

Oparaeke, A. M., Dike, M. C. and Amatobi, C. I. 2005. Evaluation of botanical mixtures for insect-pests management on cowpea plants. *Journal of Agriculture and Rural Development in the Tropics. Subtropics* 106(1): 41–48.

Ranum, P., Peña-Rosas, J. P. and Garcia-Casal, M. N. 2014. Global maize production, utilization, and consumption. *Annals of the New york Academy of Sciences,* 1312(1):.105-112.

Raheja, A. K. 1976. Assessment of losses caused by insect pests to cowpea in northern Nigeria. Pans, 22: 229-233.

Rosulu, H. O., Oni, M. O., Ofuya, T. I. and Adebayo, R. A. 2022. Bioefficacy of chilli pepper, *Capsicum frutescens* (L.) and its intercropping on the growth, yield and insect pest management of cowpea *Vigna unguiculata* (L.) Walp in the rainforest area of Nigeria. *Journal of Global Agriculture and Ecology*. 13(2): 7 - 8. ISSN: 2454 - 4205.

Sola, P., Mvumi, B. M., Belmain, S. R., Ogendo, J. O., Mponda, O., Kamanula, J. F., Nyirenda, S. P. and Stevenson P. C. 2014. Botanical pesticide production, trade and regulatory mechanisms in sub-Saharan Africa: making a case for plant-based pesticidal products. *Food Security,* 6: 369 – 384.

Pathogenicity of fungi associated with yam rot disease of *Dioscorea alata* and their effect on tuber quality

[1,2] **Abdulmujib, Y. G. and [2]Aduramigba-Modupe, A. O.***

[1] King Saud University, College of Food and Agriculture, Plant Protection Department;
[2] University of Ibadan, Faculty of Agriculture, Crop Protection and Environmental Biology

ABSTRACT

Many pathogens have been reported to be associated with tuber rots of yam. These reduce the yield and economic value of the crop. A diagnostic probe, including visual and microscopy parameters, was carried out to determine the pathogenicity of fungi associated with tuber rot in *Dioscorea alata* and their effect on yam nutritive value. Thirty-two yam tubers were obtained from the International Institute of Tropical Agriculture (IITA) yam barn in Ibadan. Yam tubers showing various symptoms were selected, and pieces of the diseased portion were taken for isolation using standard procedures. The pathogenicity of the fungal isolates was tested using a tuber inoculation assay. *Aspergillus niger, Aspergillus flavus, Rhizopus stolonifer,* and *lasiodiplodia theobromae* were isolated from rotted yam and they were found to be pathogenic on yam. *Aspergillus niger* and *Lasiodiplodia theobromae* were the most pathogenic among the fungi isolates with 49.91 % and 38.2 % rot severity respectively. The proximate analysis result showed an appreciable reduction in the nutritional composition of infected water yam. The percentage of dry matter composition (88.39 %) was lowest in yam tuber infected by *Rhizopus* sp., this was followed by yam tuber infected by *Aspergillus niger*. *A. niger* and *L. theobromae* also affected the quality and nutrient composition of yam. The study highlights the significant impact of fungal pathogens on tuber rot in *Dioscorea alata* (water yam), with *Aspergillus niger* and *Lasiodiplodia theobromae* being the most pathogenic. This study showed that these fungi are not only responsible for rot in yam tubers but can also cause a significant decrease in the nutritional composition and quality of yam tubers. Therefore, understanding the impact of these pathogens is crucial for developing effective management strategies to protect crop yield and economic value.

Key words: *Aspergillus niger*, *Lasiodiplodia theobromae*, Proximate analysis, Tuber quality, Yam rot

Corresponding author: fyaduramigba@yahoo.com

INTRODUCTION

Yams (*Dioscorea* spp.) are members of the Dioscoreaceae family. It is a tuber crop that is one of the world's most essential staple foods, especially in the tropics and subtropics (Okigbo and Ogbonna, 2006). It is impossible to overstate the importance of yams in the food economy of most West African countries. It is one of the most important sources of nutritional energy produced in the tropics. After harvest and storage, the average profit per seed yam was projected to be over US$13 000 per hectare harvested, and over 70% of Nigerians farm yams as a primary source of income (IITA, 2013, Danquah *et al.*, 2022; Wumbei *et al.*, 2022).

There are hundreds of *Dioscorea spp,* both wild and domesticated. *D. rotundata,* white yam, is the most important species, particularly in the dominant yam production zones of West and Central Africa. Like the yellow yam, *D. cayenensis*, is native to West Africa. The second most farmed species, *D. alata*, is the world's most extensively spread species, having originated in Asia. West and Central Africa account for roughly 94% of global yam production (FAOSTAT, 2021). Wumbei *et al.* (2022), with Nigeria being the leading producer (IITA, 2007; Azeteh *et al.*, 2019). Even the United Nations has expressed worry over post-harvest storage losses, stating that further reduction of post-harvest food losses in developing countries should be addressed. This is necessary as food losses after harvest are a major source of food insecurity in Africa (AMCOST, 2006; Totobesola *et al*., 2022).

Several ways for storing yams after harvesting have been developed. Despite its shortcomings, however, the traditional yam barn remains the most popular yam storage method among farmers. Although losses of up to 50% of fresh matter are possible (Amusa *et al*., 2003; Nyadanu *et al*., 2014). Mechanical damage and poor handling during and after harvest are the main reasons for yam tuber loss during storage. Physiological changes within the tuber, as well as microorganism-caused storage rots, are also significant factors. Weight loss, mechanical damage, discoloration, and shriveling are all signs of yam tuber loss during storage, rendering it unfit for ingestion.

Postharvest losses account for roughly 40% of valuable yam stock (Awuah and Akrasi, 2007; Olayemi *et al.,* 2012; Stathers *et al.,* 2020), and rots caused by microbial infection diminish table quality and make healthy tubers unpalatable to consumers (Amusa, 1999). In the tropics, where the temperature and humidity are high, microbial infestation and the spread of rots are severe. *Aspergillus flavus*, *A. niger*, *A. tamari*, *Botryodiplodia theobromae*, *Cladosporium herbarium*, *C. sphaerospermum*, and *Cylindrocarpon radiocola* are the representative fungal (Aduramigba *et al*., 2010) and bacterial pathogens implicated in the development and spread of rots., Representative spoilage bacteria include *Corynebacterium* spp., *Serratia* spp., and *Erwinia* spp. (Okigbo, 2004).

Diseases are responsible for 25% of yam post-harvest losses in storage (Ikotun, 1989), which could ultimately amount to about 80 % annually (Mabou *et al*., 2020). Insects, nematodes, and poor handling allow fungal infections to enter tubers through wounds (Amusa *et al*., 2003). Known to be quite common and highly pathogenic are the three common genera of *Lasiodiplodia*, *Fusarium*, and *Penicillium* (Noon, 1978, Adeniji *et al*., 2020). *Fusarium* species, the most frequent of which are *Fusarium oxysporium* and *Fusarium solanii*, produce the rots (Nwankiti, and Arene, 1978). *Penicillium oxalicum*, one of the well-studied rot-associated fungi, can grow on top of the bark, whereas *Lasiodiplodia theobromae*, the most prevalent, was the first parasitic fungus related to tuber rot (Aderiye and Ogundana 1984).

Yams are highly prized food crops that are high in carbs, vitamins, and dietary fibers (Ekefan *et al*., 1999; Ogaraku and Usman, 2008), as well as in therapeutic qualities for the treatment of diabetes and hypercholesterolemia (Okigbo and Ogbonna, 2006). Yam can be eaten boiled, fried, or roasted, and in yam pastes and a few confectioneries. Yam is also grown in Nigeria as a variety of staples that are processed into intermediate end products for direct intake by animals (Okaka *et al*., 1991), as well as basic ingredients for snacks and flour. Yam is rich in alkaloid content that confers special medicinal properties on yam. Yam produces antioxidants that may assist in inflammation reduction (Bantilan, 2019). Rots degrade the quality of yam tubers, rendering them undesirable to customers (Raphael *et al*., 2015.). In Nigeria, yam storage losses are high, largely due to rot, as a result, demand for yam tubers has consistently outstripped supply (FAO, 1998). In Nigeria, more than half of the yam tubers grown and harvested are lost in storage.

It is therefore necessary to confirm the current prevalence of fungi associated with yam tuber rot and to determine their effect on nutritional quality. Therefore, this work aimed to identify the pathogens that are associated with the tuber rot of water yam during storage and establish their impact on the nutrient composition of tubers.

MATERIALS AND METHODS

Source of yam tubers

Thirty-two yam tubers showing symptoms of both dry and soft rot were obtained from the International Institute of Tropical Agriculture, Ibadan, Nigeria, and the tubers were taken to the Pathology Laboratory of the University of Ibadan, Nigeria, for isolation and identification of associated myco-pathogens.

Examination of yam tubers for classification of rot

Rot was hand felt, visualized under a stereo microscope for detailed examination, and categorized as dry or soft rot. Soft rots are observed as squashy and ramified by the fungal mycelium. Dry rots are categorized when infected tissues are hard, disfigured, and with various colorations (Amusa *et al.*, 2003). Percentage rot severity was estimated as the proportion (by weight) of the rotted portion to the whole tuber without the rot portion, using the following equation:

$$\%\, Rot\ severity = \frac{Weight\ of\ Rotted\ portion}{Weight\ of\ whole\ tuber} \times 100$$

Isolation and identification of fungi

The part of the yam tissue showing different symptoms (5-7 mm) was cut out with a sterile sharp knife and placed on small plastic bowls. A small slice of yam tissue, encompassing the expanding boundary of rot and neighboring healthy tissue, was cut and surface-sterilized with 1.5% sodium hypochlorite. Each surface-sterilized sample was rinsed in three changes of sterile distilled water and allowed to air dry before being transferred onto the already prepared Potato Dextrose Agar plates for inoculation under the inoculating chamber. On each plate, three peeled sections were arranged with an equal distance between them and were incubated at 28 °C for 5-7 days. The identification of isolates was done by examining them macroscopically and microscopically. The colony characteristics, spores, mycelium, and conidia were observed. The fungal pathogen was identified using the illustration chart of Barnet and Hunter (1998).

Pathogenicity test

Healthy whole yam tubers were collected, and the initial weight of each tuber was determined. The yam tubers were rinsed with distilled water and surface sterilized for one minute using a 1% sodium hypochlorite solution. Sterilized whole yam tubers were inoculated according to the method described by Sangoyomi (2004). A 6 mm diameter cork borer was driven to a depth of about 10 mm into the yam tubers to create wounds on the yam. Agar blocks of mycelium from the culture of the isolate were deposited into the wound and covered with the tissue that was removed with the aid of the cork borer. The inoculated tubers were enclosed in a polythene bag, few drops of sterile distilled water were introduced into the bag to increase the relative humidity of the environment. The bags were kept and watched for 14 days. At the end of the inoculation period, inoculated tubers were sliced at the points of inoculation and assessed for the presence or absence of rots. Mycelia and spores from the tuber were surface-scraped onto prepared PDA, and the different fungi that were re-isolated were compared with the original isolates.

Proximate analysis

Proximate composition analysis (AOAC, 2005) was conducted to determine the

Moisture Content, Crude Protein, Crude Fat, Ash Content, and Crude Fiber to establish the nutritive components of healthy yam and rotten yam tuber. Data collected were subjected to analysis of variance, while means were separated using Duncan's Multiple Range Test at a 5% significance level.

RESULTS AND DISCUSSION

Fungi identified from infected yam samples

Four fungi species were identified from infected yam tuber samples. The fungal isolates were *Aspergillus niger, Aspergillus flavus, Rhizopus stolonifer, and Lasiodiplodia theobromae*. The morphological and cultural characteristics of the fungi were observed. The culture of *A. flavus* was yellowish to light green. *Aspergillus niger* had a dark-greyish mycelial growth. *Rhizopus* formed a white woolly mycelium, and *L. theobromae* grew as a spongy white culture at three days old, but gradually turned black (Table 1). Their frequency of occurrence is presented in Figure 1.

Table 1. Cultural and microscopic characteristics of fungal isolates

Fungal isolates	Colony description	Body view under the microscope
Aspergillus niger	Colonies are blackish brown in the culture plate	Conidiophores are rough-like and non-septate, and arise from a thick-walled foot cell
Aspergillus flavus	Brownish green color surrounded by a hallow	Conidiophore is non-septate and arises from a thick-walled foot cell. Conidiophores are smooth and colorless
Rhizopus stolonifera	The whitish woolly appearance that grows rapidly	Sporangiophore extends from an elongated stolon and ends with a spherical, black-colored sporangium
Lasiodiplodia theobromae	The culture was spongy white at 3 days old, but gradually turned black	Conidia are dark brown with longitudinal striation, with an observation central septum

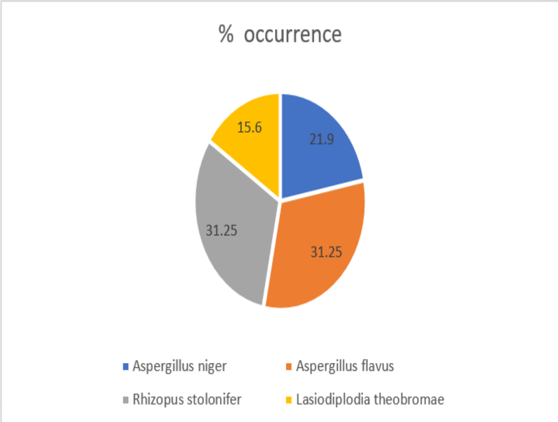


Figure 1: Frequency of occurrence of fungi isolated from infected yam tubers

Pathogenicity of the isolates on yam tubers

The result of the pathogenicity test showed that, at room temperature and high relative humidity, all tested fungi were pathogenic on *Dioscorea alata* (Tables 2 and 3). The rot symptoms caused by *A. niger* were soft and pinkish. *Aspergillus flavus* caused brownish soft rot symptoms, *R. stolonifer* caused pinkish-brown soft rot symptoms, and *Lasiodiplodia theobromae* caused soft rot with a dirty black color. *Aspergillus niger* and *Lasiodiplodia theobromae* were the most pathogenic among the fungi isolated. They reduced tuber weight by 22.5% and 17.5%, respectively. This was followed by *A. flavus,* causing a weight reduction of 12.5%. The least pathogenic isolate was *R. stolonifer* with only a 10% reduction in tuber weight (Table 4).

Table 2. Effect of inoculated fungi on yam tuber rot at room temperature

Fungi	Size of rot (cm)
Aspergillus niger	2.7 ± 0.16 a
Aspergillus flavus	1.9 ± 0.09 bc
Rhizopus stolonifer	1.7 ± 0.04 c
Lasiodiplodia theobromae	2.1 ± 0.05 b
Control	No visible rot

Real means ± standard error of real means (Tukey's HSD where $p \leq 0.05$). Means within the same column followed by the same letters are not significantly different at $p \leq 0.05$.

Table 3. The severity of damage caused by fungi isolate on healthy yam tubers

Fungi	Damage (%)
Aspergillus niger	49.91
Aspergillus flavus	30.2
Rhizopus stolonifer	29.31
Lasiodiplodia theobromae	38.2
Control	0.0

Table 4. Effect of isolated fungi on the weight of yam tubers

Fungi	Weight reduction (%)
Aspergillus niger	22.5
Aspergillus flavus	12.5
Rhizopus stolonifer	10.0
Lasiodiplodia theobromae	17.5
Control	0.0

Proximate analysis

The proximate analysis showed that uninoculated, healthy yam had the highest percentage for all compositional nutrients and dry matter measured in this study. The percentage composition of dry matter was lowest in yam tuber inoculated with *R. stolonifer,* with 88.39%; yam tuber inoculated with *A. flavus* had the highest percentage composition of dry matter. The result of the nutritional composition analysis is presented in Table 5. The current study revealed that active storage rot of yams is caused by *Aspergillus niger, Aspergillus flavus, Rhizopus stolonifer, and Lasiodiplodia theobromae*. These fungal isolates have been previously associated with tuber rots of yams in storage (Gwa *et al*., 2018; Mabou *et al*., 2020). All the fungi isolates were able to cause the same symptoms that were observed on the diseased yam from which they were isolated. This observation was corroborated by the work of Gwa *et al.* (2017), who also isolated fungi from yams in Nigeria. This shows that these fungi are important agents in post-harvest losses of yam during storage.

Fewer fungal species were isolated in the current study compared to the report of Ogunleye and Ayansola, (2014). This may be a result of the differences in storage methods used for the sources from which the two sets were collected. The yams used in this study were collected from the yam barn of IITA, while the yams used by Ogunleye and Ayansola, (2014) were collected from an open market store. This implies that the storage method for yams may be a factor in incidents of storage infection. Also, the yams collected for the current study were stored yams, with reduced moisture content (due to storage duration), compared to freshly harvested yams. This may also be a reason for the lower number of microflora encountered in the study. Low moisture content has been suggested as a requirement for storage when long-term holding is intended (Fauziah *et al*., 2020). Thus, it could be suggested that the moisture content of yams should be reduced before subjecting them to long-term storage. Also, further work is required to establish the correlation between moisture content and the number of fungal organisms associated with the rot of yam tubers in storage.

Table 5. Proximate composition of healthy and infected yam tubers

Treatment	%CP	%ASH	%EE	%CF	%DM
Control	4.55±0.05a	4.00±0.03a	0.50±0.05a	1.50±0.03a	90.12±0.39a
Rhizopus stolonifer	3.50±0.02c	3.00±0.04b	0.30±0.05a	1.00±0.03b	88.39±0.41b
Aspergillus flavus	2.45±0.04b	3.00±0.02b	0.40±0.04a	1.00±0.01b	90.06±0.25b
Lasiodiplodia theobromae	2.46±0.04b	2.00±0.02b	0.30±0.01a	1.10±0.02b	89.91±0.32b
Aspergillus niger	3.52±0.03c	3.00±0.03b	0.40±0.02a	1.20±0.02b	89.54±0.22b

Means followed by the same letter within a column are not significantly different at $p \leq 0.05$ using Duncan's multiple range test; numbers of replicates = 3. (CP=Crude protein, EE=ether extract, CF=Crude fibre, DM=Dry matter)

The organism associated with the rot of water yam in this study were *Aspergillus niger, Aspergillus flavus, Rhizopus spp., and Lasiodiplodia theobromae*. These fungi have been associated with post-harvest rots (Okigbo, 2004; Adeniji *et al*., 2020). *Aspergillus flavus* and *Rhizopus stolonifera* have the highest frequency of occurrence, and this is in line with the previous works of Ogunleye and Ayansola (2014). The pathogenicity capacity of fungal isolates significantly differed ($p \leq 0.05$) after re-inoculation of healthy yam tubers (Table 2). *Aspergillus niger* showed the highest pathogenicity, followed by *Lasiodiplodia theobromae* causing lesions ranging from 2.7 to 2.1 cm in diameter 14 days after inoculation. Rot in storage, most likely, begins in the soil and proceeds during storage. Microorganisms enter yams through natural holes and wounds that occur during harvesting and transportation from the field to the storage barn (Gao *et al*., 2023).

The proximate composition result showed that the crude protein, crude fibre, and dry matter components of the yam tubers are affected by the isolates. Significant reduction is observed in the infected yams except for the ether extract. The proximate composition of the current study reveals that the nutritional composition of yam can be compromised upon infection, and this effect continues during storage. Similar outcomes have been previously noted, particularly in the work of Eneogwe *et al* (2022). Rot severity varied depending on the isolated myco-pathogens. Fungi were found to be responsible for more than 60% of all yam tuber rots in Nigeria, according to Ikotun (1989), and about thirty distinct fungi were isolated from preserved yams. These findings were comparable to those of Agbejule *et al* (2017), Shiriki *et al* (2015) and Amusa and Baiyewu (1999), who identified *Aspergillus, Penicillium*, and *Rhizopus* as rot pathogens associated with stored and marketed yam tubers from Southwestern Nigeria's tropical forest zone. These findings corroborate those of Adeniji (1970), and Ikotun (1989) who identified *Aspergillus niger* and *Lasidioplodia theobromae* as the cause of severe yam degradation in Nigeria.

CONCLUSION

Aspergillus niger, Aspergillus flavus, Rhizopus spp., and Lasiodiplodia theobromae were identified as rot-associated pathogens in this study, the pathogens invade yam tissues, causing decolorization and lesions along the site of infection. These infections significantly impaired the quality and nutrient composition of yams. It is, therefore, essential to develop safe and accessible control measures specific to these rot pathogens. Also, understanding the pathogenicity of these fungi and implementing effective control measures are crucial for maintaining yam tuber quality.

REFERENCES

Adeniji, A., Taiga, A. and Ayodele, M. S. 2020. Comparative studies on the susceptibility of three tubers of Dioscorea species to dry rot in Anyigba, Kogi State. *International Annals of Science*, 8(1): 70-74.

Adeniji, M. O. 1970. Fungi associated with storage decay of Yam in Nigeria. *Phytopathology*, 60(4): 590-592.

Aderiye, B. I., and Ogundana, S. K. 1984. Survival of *Botryodiplodia theobromae* in yam tissues. In *Tropical root crops: production and uses in Africa: proceedings of the Second Triennial Symposium of the International Society for Tropical Root Crops-Africa Branch held in Douala, Cameroon, 14-19 Aug. 1983*. IDRC, Ottawa, ON, CA.

Aduramigba-Modupe, A.O., Odebode, A.C. and Asiedu, R., 2010. Distribution of yam anthracnose disease in Nigeria. *Afr. J. Root Tuber Crops*, *8*(1), pp.51-55.

Agbejule, A. A., Aduramigba-Modupe A. O. and Sangoyomi, T. E. 2017. Evaluation of plant extracts for the control of post-harvest fungal spoilage of yam tubers (*Dioscorea rotundata* Poir.) *African Journal of Root and Tuber Crops* V13 (1): 20 – 28.

AMCOST 2006. Technologies to reduce post-harvest food loss The African Ministerial Council on Science and Technology (AMCOST) of the African Union (AU), Pretoria, South Africa, From http://www.nepadst.org/platforms/foodloss.shtml.

Amusa, N. A., Adegbite, A. A., Muhammed, S. and Baiyewu, R. A. (2003). Yam diseases and their management in Nigeria. *African Journal of Biotechnology*, 2(12): 497-502.

Amusa, N. A., and Baiyewu, R. A. 1999. Storage and market disease of yam tubers in southwestern Nigeria. *Ogun Journal of Agriculture Research*, 11: 211-225.

AOAC. 2005. Official methods of analysis of the Association of Analytical Chemists International. *OfficialMethods: Gaithersburg, MD, USA*.

Awuah, R. T. and Akrasi, K. O. 2007. Suppression of tuber rot of yam caused by *Aspergillus niger* with a Yam Rhizobacterium. In *Proceedings of the 8th African Crop Science Society Conference* (8: 875-879).

Azeteh, I. N., Hanna, R., Sakwe, P. N., Njukeng, A. P. and Kumar, P. L. 2019. Yam (*Dioscorea* spp.) production trends in Cameroon: A review. *Afr. J. Agric. Res*, 14(26): 1097-1110.

Bantilan, C. 2019. Nutrition. 11 health and nutrition benefits of yams. *Healthline Media, Inc.: New York, NY, USA*.

Barnett, H. and Hunter, B. 1998. Illustrated genera of imperfect fungi. 4th Edition, 2nd printing. *American Phytopathological society press,* St. Paul, Minnesota. 218 pp.

Ekefan, E. J., Simon, S. A., Nwankiti, A. O., and Peter, J. C. 1999. Effect of intercropping on the incidence of foliar anthracnose and tuber yield of susceptible *Dioscorea alata*; yam in Nigeria. *J. Plant Protec. in the Tropics*, 12(2): 80-90.

Eneogwe, G. O., Ibrahim I. E. and Obuye, F. 2022. Proximate Composition, Levels of Some Essential Mineral Elements and Anti-Nutritional Components of Some Yam Species Found in Minna, Niger State. *Biology, Medicine, and Natural Product Chemistry*, 12(1): 9-16.

FAO AND UNEP 1981: Food Loss Prevention in Perishable Crops. FAO Agricultural Services Bulletin No. 43. Rome: FAO.

FAOSTAT. 2021. Food and Agriculture Organization of the United Nations. FAOSTAT Statistical Database. Rome. Available at: https://fao.org/faostat/en/#compare (assessed October 15, 2022).

Fauziah, F., Mas' udah, S., Hapsari, L. and Nurfadilah, S., 2020. Biochemical composition and nutritional value of fresh tuber of water yam (Dioscorea alata L.) local accessions from East Java, Indonesia. *AGRIVITA, Journal of Agricultural Science*, 42(2): 255-271.

Food and Agricultural Organisation. (2007). Food and Agriculture Organization Production Year Book. FAO Rome.

Food and Agriculture Organisation. (1998). FAOSTAT Agriculture Database – Agriculture Production crops Primary, Fao@www.fao.org.

Frank, C. O. and Kingsley, C. A., 2014. Role of Fungal rots in post-harvest storage losses in some Nigerian varieties of Dioscorea species. *British Microbiology Research Journal*, 4(3):.343-350.

Gao, J., Hu, X., Xiao, R., Luo, F., Tang, Y., Luo, J., and Guo, M. 2023. The microbiome and typical pathogen multiplication, qualities changes of baoxing yam at different storage temperatures. *LWT*, *188*, 115402.

Gwa, V. I., Ekefan, E. J. and Nwankiti, A. O. 2017. Antifungal Potency of Some Plant Extracts in the Control of White Yam (*Dioscorea rotundata* Poir) Tuber Rot. *Adv Biotech and Micro*, 7(1)….

Gwa, V. I., Nwankiti, A. O. and Hamzat, O. T. H. 2018. Antimicrobial activity of five plant extracts and synthetic fungicide in the management of postharvest pathogens of yam (*Dioscorea rotundata* Poir) in storage. *Acad. J. Agric. Res*, 6(6): 165-175.

IITA 2007. Yam. Research Review. International Institute of Tropical Agriculture, Ibadan, Nigeria. Pp.1-4.

IITA 2013. Healthy yam seed production. IITA Publications.

Ikotun, T. 1989. Diseases of Yam tubers. *Int. J. Trops plants Dis*. 7: 1 – 21.

Kwoseh, C.K., Plowright, R.A., Bridge, J. and Asiedu, R., 2007. Search for *Scutellonema bradys* resistance in yams (Dioscorea spp.). *Journal of Science and Technology (Ghana)*, *27*(3), pp.39-42.

Mabou, L. C. N., Sameza, M. L., Tchameni, S. N., Eke, P., Toghueo, R. M. K., Albertini, A., and Boyom, F. F. (2020). Molecular Identification of Fungal Pathogens Associated with Post-harvest Yam Tubers Rot in Mbam et Kim Division (Cameroon) with Emphasis on *Penicillium monomenatosum* (Frisvad, Filt. & Wicklow) as a First Report. *American Journal of Microbiological Research*, *8*(2), 73-78.

Noon, R. A. (1978). Storage and market diseases of yams. *Tropical Science*. 20(3): 177-188

Nwankiti, A. O., and Arene, O. B. (1978). Diseases of yam in Nigeria. *Pans*, *24*(4), 486-494.

Nyadanu, D., Dabah, H., and Agyekum, A. D. (2014). Resistance to post-harvest microbial rot in yam: integration of genotype and storage methods. *African Crop Science Journal*, *22*(2), 89-95.

Ogaraku, A. O., and Usman, H. O. (2008). Storage Rot of Some Yams (*Dioscorea* spp) in Keffi and Environs, Nasarawa State, Nigeria. *Patnsuk J*, *4*(2), 22-27.

Ogundana, S. K., Naqvi, S. H. Z., and Ekundayo, J. A. (1970). Fungi associated with soft rot of yams (*Dioscorea* spp.) in storage in Nigeria. *Transactions of the British Mycological Society*, *54*(3), 445-451.

Ogunleye, A. O., and Ayansola, O. T. (2014). Studies of some isolated rot-causing mycoflora of yams. *Am. J. Microbiol. Biotechnol*, *1*(1), 9-20.

Okaka, J. C., Okorie, P. A. and Ozo, O. N. 1991. Quality evaluation of sun-dried yam chips. *Tropical science*, 31(3): 265-275.

Okigbo, R. N. 2004. A review of biological control methods for post-harvest yams (*Dioscorea* spp.) in storage in South-Eastern Nigeria. *Current Applied Science and Technology*, 4(1): 207-215.

Okigbo, R. N. and Ogbonnaya, U. O. 2006. Antifungal effects of two tropical plant leaf extracts (*Ocimum gratissimum* and *Aframomum melegueta*) on postharvest yam (*Dioscorea* spp.) rot. *African Journal of Biotechnology*, 5(9)…….

Olayemi, F. F., Adegbola, J. A., Bamishaiye, E. I. and Awagu, E. F. 2012. Assessment of post harvest losses of some selected crops in eight local government areas of rivers state, Nigeria. *Asian journal of rural development*, 2(1): 13-23.

Oluwagbenga, A. O., Adedotun, A. A., Temitope, S. O. and Margaret, E. A., 2014. Studies on fungi isolated from *Dioscorea rotundata* collected from open markets in Lagos Nigeria. *International Journal of Phytopathology*, *3*(3), pp.139-147.

Opara, L.U. (1999) Yam Storage. In: Bakker-Arkema, F.W., Ed., CIGR Handbook of Agricultural Engineering 171 Volume IV Agro-Processing, The American Society of Agricultural Engineers, St. Joseph, 182-214.

Osagie, A. U. (1992). *The yam tuber in storage*. Postharvest Research Unit. University of Benin, Benin City, Nigeria. pp: 247.

Owusu Danquah, E., Danquah, F. O., Frimpong, F., Dankwa, K. O., Weebadde, C. K., Ennin, S. A., and Opoku, A. Y. (2022). Sustainable intensification and climate-smart yam production for improved food security in West Africa: a review. *Frontiers in agronomy*, *4*, 858114.

Raphael, O. N., Ebere, E. C., Kingsley, A. C., Chidiebere, I. R., Chidi, O. B., Nsikak, A. S. and Confidence, I. A. 2015. Control of white yam (Dioscorea rotundata) rot pathogen using peel extract of water yam (Dioscorea alata). *Advances in Applied Science Research*, 6(10): 7-13.

Sangoyomi, T. E. 2004. Post-Harvest Fungal Deterioration of Yam (*Dioscorea rotundata*. Poir) and Its Control. PhD Thesis, IITA, Ibadan, Nigeria, 179 p.

Shiriki, D., Ubwa, S. T. and Shambe, T. 2015. Isolation of nine microorganisms from rotten Dioscorea rotundata (white yam) and antimicrobial sensitivity test with five plant extracts. *Food and Nutrition Sciences*, 6(10): 825.

Stathers, T., Holcroft, D., Kitinoja, L., Mvumi, B. M., English, A., Omotilewa, O. and Torero, M. 2020. A scoping review of interventions for crop postharvest loss reduction in sub-Saharan Africa and South Asia. *Nature Sustainability*, 3(10): 821-835.

Totobesola, M., Delve, R., Nkundimana, J. D. A., Cini, L., Gianfelici, F., Mvumi, B. and Rolle, R. S. 2022. A holistic approach to food loss reduction in Africa: food loss analysis, integrated capacity development and policy implications. *Food Security*, 14(6): 1401-1415.

Wumbei, A., Kengirir, S., Gautiei, N., Kwodanga, J. K., Joseph, D. F. and Galani, Y. J. A. 2022. State of the art of yam production. In: Kaushi P, editor. Advances in root and vegetable research. IntechOpen. DOI: https://doi.org/10.5772/intechopen.106504.

Cocoa seedling growth response as affected by variety and bean storage duration in dodecahedron device

Joseph-Adekunle, T. T.*, Taiwo A.O. and Hammed L. A.

Department of Horticulture
Federal University of Agriculture Abeokuta

ABSTRACT

The effects of two cocoa varieties' bean stored for varying duration in a dodecahedron pyramidal device were assessed. Cocoa bean is prone to loss of viability post extraction which poses a challenge to cocoa nursery operators and farmers. The two cocoa varieties used were Polyclonal (developed) and F3 cultivar (undeveloped) and were stored for 0, 24, 48, and 72 hours before sowing. Data were collected on germination percentage, number of leaves, plant height, stem girth, leaf area, and dry weights of shoots and roots. Results showed that seeds sown immediately (0 hour) had the highest germination rate, while delay in storage resulted in reduced performance. The dodecahedron pyramidal device had minimal benefit and appears more useful for very short-term storage of fresh seeds and improved varieties for better seedling performance.

Key word: Cocoa, seedling growth, storage device, storage duration

***Corresponding author**: joseph-adekunlett@funaab.edu.ng

INTRODUCTION

Cocoa (*Theobroma cacao* L.) belongs to the *Malvaceae* family and naturally grows in the lower canopy of tropical rain forests. It was first discovered in the Amazon Basin in the 18th century and has since spread to South and Central America, as well as West Africa, which became a major producer from the 1960s. Modern molecular studies have reclassified cocoa into the *Malvaceae* family. It is a perennial tree crop of major economic importance globally. West Africa produces over 70% of the world's cocoa beans (FAO, 2022). Cocoa plays a key role in rural livelihoods and serves as the main raw material for the chocolate industry. Successful cultivation starts with strong and healthy seedlings, which ensure good field establishment and high yield potential (Aikpokpodion *et al.*, 2021). It thrives in tropical environments with warm temperatures, high humidity, and fertile, well-drained soil. The tree naturally grows under the shade of taller trees in rainforests and prefers moist conditions.

Several factors affect cocoa seedling performance. These include the genetic characteristics of the seed, environmental conditions, and pre-planting seed treatments (Adeyemi *et al.*, 2020). Improved varieties, such as Polyclonal types, are bred for better performance, while local or undeveloped types like the F3 cultivar tend to have variable and weaker growth patterns (Oluyole and Lawal, 2021). Seed storage is another crucial factor in cocoa propagation. Cocoa seeds are recalcitrant, meaning they lose moisture and viability quickly if not planted soon after harvest (Nkang *et al.*, 2020). This makes it essential to handle and store them properly before planting.

In recent years, interest has grown in non-traditional agricultural techniques, including the use of energy-based or geometric structures such as pyramids. One such structure is the dodecahedron pyramidal device. It is believed to create a unique microclimate or energy field that may influence seed performance and early plant growth (Singh and Prakash, 2022). Although scientific evidence is limited, some studies report improvements in germination and seedling growth when seeds are exposed to pramidal environments (Gupta *et al.*, 2023; Rahman *et al.*, 2024).

MATERIALS AND METHODS

The experiment was conducted in the Screen house of COLPANT), Federal University of Agriculture, Abeokuta, (FUNAAB) (Longitude 7° 15 N and Latitude 3° 25 E) in Odeda Local Government area , Ogun state, Nigeria. The vegetation is between the tropical rainforest and derived savannah (Google Earth, 2021). The cocoa pods were obtained from the cocoa trees at COLPANT, FUNAAB) and Cocoa Research Institute of Nigeria (CRIN) at Idi-Ayunre Oluyole Local Govt. Area Ibadan Oyo State.. A 2 × 4 factorial experiment was laid out in a Completely Randomized Design (CRD) and replicated three times.

Factor A - Cocoa variety: Polychlonar (Developed variety) and F3 cultivar (Undeveloped variety

Factor B – Storage duration: No storage or control: 0Hour, 24 hours (24 H), 48 hours (48H) and 72 hours (72H). The total treatment combination was 24 experimental units.

Top soil was collected, sieved and potted into 15 x 30 cm nursery bags and arranged in the screen house at COLPANT. The bean was sown at the rate of one seed per polythene bag from each of the cocoa variety and storage duration. The set up was watered twice in a day (morning and evening) for the first two weeks and once in subsequently. Data were collected on the following parameter:

Germination parameter:

Percentage germination - this was determined by counting the number of seedlings that emerged per treatment divided by the total number of seed sown for each treatment and then multiply by 100 percent.

Growth parameters: Plant height (cm) - It was determined by measuring the seedling with metre rule from ground level to the apical region of the stem at two weekly intervals between 5 and 15 weeks after sowing; Number of leaves per plant - Number of fully open and green leaves per plant were counted and recorded for each treatment at two-week interval starting from 4 to 16 weeks after sowing; Stem girth (mm) - It was measured using a Vernier calliper at two week interval from 4 to 16 weeks after sowing; Leaf area (cm²) - The leaf area was determined at 2-week interval from 4 to 6 weeks after sowing using a non-destructive method which involves multiplying the leaf length by the leaf breadth which in turn is multiplied by leaf area factor of cocoa (0.75).

$$\text{Leaf area (cm2)} = L \times B \times LAF$$

where: L = Length of leaf (cm); B = Breadth of leaf (cm); LAF = Leaf Area Factor of Cocoa (0.75) (Adeninkinju, 1974)

Plate 1: A photo of Dodecahedron Pyramidal storage device

RESULTS

Effects of storage duration in a Dodecahedron pyramidal device on germination of two cocoa bean varieties

The freshly extracted bean (unstored) cocoa beanm of PC variety had highest germination percentage followed by F3 variety stored for 24H. Other storage durations in recorded lower percentages with longer storage durations (Figure 1). This is line with assertion of Olaiya (2016) that cocoa bean loses viability within 5 to7 days post extraction unless specially treated.

Effect of Storage Duration on Plant height (cm) of two Cocoa varieties

The Polyclonal variety produced taller seedlings irrespective of the storage duration. In contrast, to F3 cultivar which had highest seedling height in control 0 H and 24 hours, but with suppressed at longer storage durations. However, at 13 weeks after sowing for the 72-hour duration the seedlings height equalised, this suggests that F3 cultivar may overcome early storage-induced stress over time (Figure 2).

Effects of Storage Duration in a Dodecahedron pyramidal device on Number of Leaf of two Cocoa Varieties

The freshly extracted unstored bean and 72-hour storage durations of Polyclonal variety produced seedlings with relatively stable and progressive leaf formation. The F3 variety was characterized with variation in leaf formation, especially under 48-hour storage, though it ultimately achieved near-uniform leaf counts across treatments by the 13 weeks after sowing (Figure 3).

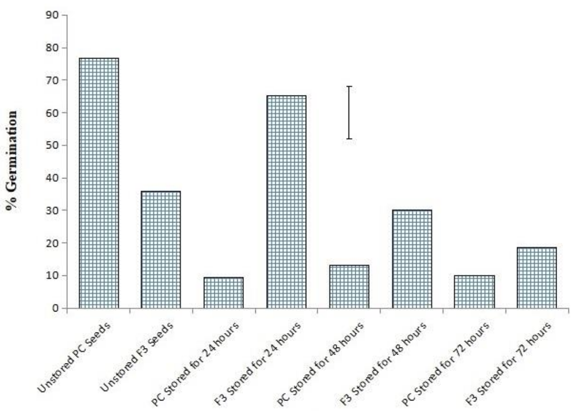


Figure 1. Germination percentage of cocoa seeds as affected by longevity of storage in Dodecahedron pyramidal device

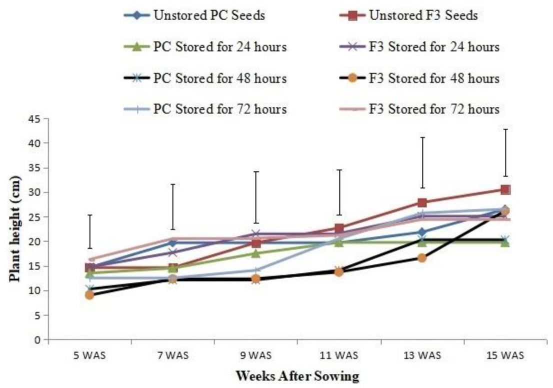


Figure 2: Plant height (cm) of cocoa seedlings as affected by longevity of seed storage in Dodecahdron pyramidal device

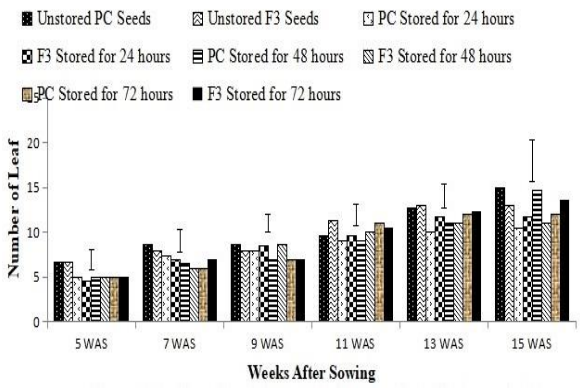


Figure 3: Number of leaves of cocoa seedlings as affected by longevity of seed storage in Dodecahdron pyramidal device

Effect of Storage Duration on Stem Girth of Cocoa Varieties

The data show an overall slight increase in stem girth over time under most treatments. However, the 24-hour storage group experienced a notable decrease from 4.3 cm to 3.3 cm, indicating a potential negative effect of short-term storage on stem thickness. The 72-hour group, by contrast, improved from 4.0 cm to 4.4 cm, suggesting a delayed but positive growth response. F3 cultivar displayed strong early growth, particularly under 24-hour and 48-hour storage. However, a decline in stem girth was observed for the 48-hour group at the 13th week, dropping from 4.7 cm to 3.9 cm. The 72-hour group showed a recovery in stem girth over time.

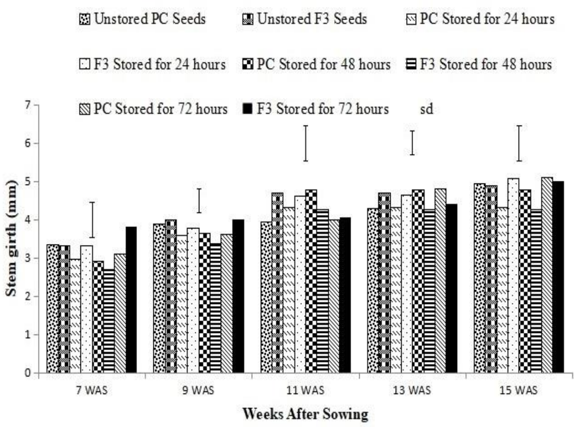


Figure 4: Stem girth (cm) of cocoa seedlings as affected by longevity of seed storage in Dodecahdron pyramidal device

Effect of Storage Duration on Total Leaf Area of Cocoa Varieties

The unstored Polyclonal seedling had the highest leaf area with 44.3 followed by the seedling stored for 72 hours with 39.1, followed by the seedling stored for 24 hours with 32.1 and the seedling stored for 48 hours had the least leaf area with 21.4 in the 11th week and that trend was also repeated in the 13th week also. For the F3 cultivar the unstored seedling had the least leaf area with hours had higher leaf area with 26.8, the seedling stored for 72 hours was a bit higher with 47.8 while the seedling stored for 24 hours had the highest leaf area with 58.9 in the 11th week and that trend was also repeated in the 13th week also 21.4, the seedling stored for 48 hour

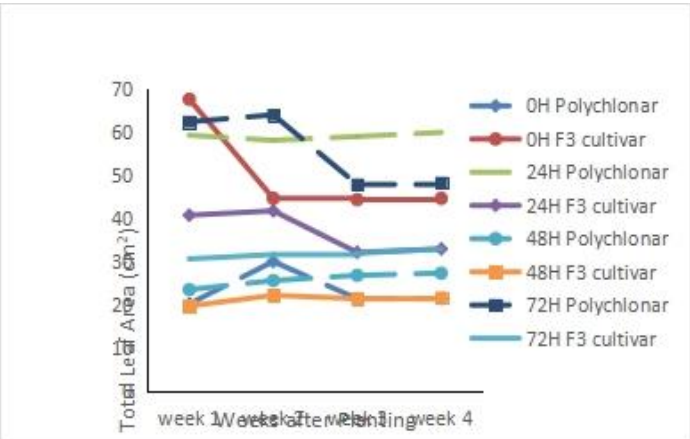


Figure 5: Total leaf area (cm^2) of cocoa seedlings (Polyclonal) as affected by longevity of seed storage in Dodecahdron pyramidal device

REFERENCES

Adeyemi, M. O., Ojo, L. A. and Babalola, T. S. 2020. Seed storage and germination performance in cocoa (*Theobroma cacao* L.). *African Journal of Agricultural Research*, 15(3): 145–153.

Aikpokpodion, P. O., Iremiren, G. O. and Adeogun, S. O. 2021. Cocoa production and sustainability in West Africa. *Journal of Tropical Agriculture*, 59(2): 178–190.

FAO. 2022. Cocoa market report. Food and Agriculture Organization of the United Nations.

Gupta, R., Sharma, V. and Patel, K. 2023. Effects of pyramidal structures on germination and seedling growth: A preliminary study. *Journal of Innovative Agriculture*, 10(4): 299–307. ISSN: 1116-753X

Nkang, A. E., Umoh, E. O. and Udo, E. S. 2020. Viability of recalcitrant cocoa seeds during storage. *Seed Science and Technology*, 48(2): 321–332.

Olaiya A. O. 2016. Growth and development of cacao (*Theobroma cacao* L.) seedlings in the nursery as influenced by pod maturity and retaining period after harvesting. *Nigerian Journal of Ecology*, 15(1): 19-23.

Oluyole, K. A. and Lawal, J. O. 2021. The impact of variety on cocoa farm productivity in Nigeria. Nigerian Journal of Agriculture and Food Security, 8(1): 88–95.

Singh, R. and Prakash, M. 2022. Investigating pyramidal energy fields in agriculture: Myth or science? *Agricultural Sciences Today*, 7(3): 210–218.

Diversity of seed mineral compositions in ten pepper (*Capsicum* spp L.) landraces

Agbonghale, D. E*. and Alake, C. O.

Department of Plant Breeding and Seed Technology,
Federal University of Agriculture, Abeokuta, Ogun State, Nigeria

ABSTRACT

The nutritional quality of crop seeds plays a crucial role in addressing micronutrient deficiencies, particularly in developing regions where malnutrition is prevalent. This study was conducted to assess the diversity in seed mineral composition among ten pepper (*Capsicum spp*) landraces with the aim of identifying genotypes with superior nutritional traits for potential use in breeding programs. The experiment evaluated six essential mineral elements: potassium (K), calcium (Ca), magnesium (Mg), phosphorus (P), iron (Fe), and zinc (Zn). Seeds were collected and analyzed using standard laboratory procedures, and data were subjected to statistical analysis using Analysis of Variance (ANOVA) to determine the significance of observed differences. Principal component analysis and cluster analysis were performed to classify the landraces based on mineral profiles. Results revealed considerable genotypic variability among the landraces for all the evaluated minerals ($P \leq 0.05$). Notably, landrace F015 exhibited the highest concentration of calcium (161.52 mg/100g) and magnesium (201.48 mg/100g), while F011 had superior iron (6.77 mg/100g) and zinc (1.19 mg/100g) levels. Potassium was highest in F015 (496.20 mg/100g), and phosphorus peaked in F020 (188.48 mg/100g). Conversely, some landraces such as F025 and F046 recorded relatively lower values across multiple minerals, indicating potential limitations for nutritional enhancement. Cluster analysis grouped the genotypes into three distinct clusters, with Cluster 1 exhibiting higher average concentrations of essential nutrients, particularly Mg, P, and Fe. The results are useful for genetic conservation, breeding programs, and addressing micronutrient deficiencies through crop-based solutions. The findings offer a valuable resource for breeders committed to sustainable crop improvement.

Key words: Breeding programs, genotypic variability, nutritional quality, seed mineral composition,

***Corresponding author**: agbonghaledivine03@gmail.com

INTRODUCTION

Pepper *(Capsicum* spp L.) are members of the genus *Capsicum*, which includes a variety of species that are cultivated worldwide for their culinary, medicinal, and economic importance. Peppers belong to the family *Solanaceae*, commonly known as the nightshade family, which also includes tomatoes, potatoes, and eggplants. They are native to the Americas, with their origin tracing back to regions in Central and South America. The genus *Capsicum* has diversified significantly, with several key species being widely cultivated and consumed globally. Pepper is the second most consumed vegetable worldwide, with 1.99 million hectares (ha) currently reserved for cultivation. In Spain, pepper occupied 20,388 ha in 2017, cultivated mainly in the Mediterranean Region, where its considerable agronomic and economic importance makes it a relevant crop. *Capsicum* cultivated species present a broad diversity in morphological and agronomic traits mostly in Central and South America, their geographical origin, as a result of evolution, domestication, and artificial and natural selection in primary and secondary centers of diversity (DeWitt and Bosland, 1996; Bartolomé Garcia *et al.*, 2015; Tripodi *et al.*, 2021). Indeed, more than five centuries of pepper selection in Europe have resulted in a great range of landraces adapted to a wide range of agro climatic conditions (Bartolomé Garcia *et al.*, 2015). Peppers provide important nutritional benefits, which make them even more valuable. Peppers' high antioxidant capacity, together with being very rich in ascorbic acid, carotene, phenols, xanthophylls, and flavonoids, make it a functional food (Howard *et al.*, 2012). Nonetheless, the proportion of these elements clearly depends on cultivar genotype and maturity stage, among other factors (Martínez *et al.*, 2005). The quality of fruits and vegetables for fresh consumption is a complex issue. While their nutritional composition is a primary factor for defining food quality, the external appearance of fruits, particularly their color and properties such as firmness and pericarp thickness, also play an important role in the quality evaluation, especially as far as consumer acceptance is concerned (Abbott, 1999).This research aims to contribute to improved nutrition, agriculture, health, and economic development by understanding the mineral diversity in pepper landraces that can help address nutritional deficiencies such as iron, zinc and calcium deficiencies which are prevalent in many rural areas in Nigeria as well as identify landraces with superior traits that can be utilized in breeding programs to develop new pepper varieties that are more nutritious and potentially more resilient to environmental stresses.

MATERIALS AND METHODS

The study was carried out at the Central Laboratory of the department of Plant Breeding and Seed Technology, Federal University of Agriculture, Abeokuta (FUNAAB) and the mineral composition was done at the biotechnology center, FUNAAB, Ogun State, Nigeria. Ten pepper landraces were sourced from Gene bank of the department of Plant Breeding and Seed Technology, Federal University of Agriculture, Abeokuta (FUNAAB). Spectroscopic determination of some seed mineral contents in *Capsicum* were tested for. The samples from each accession were analysed for seed mineral content, including Iron, Zinc, Potassium, Calcium, Magnesium and Phosphorus. The mineral contents of the samples were determined by the procedure of AOAC (2000). Calcium, magnesium, iron, sodium, potassium, copper and zinc elements were measured with Atomic Absorption Spectrophotometer (Thermo scientific S Series Model GE 712354) after digesting with a perchloric – nitric acid mixture (AOAC, 2000). Prior to digestion, 0.50 g of the samples were weighed into a 125 ml Erlenmeyer flask with the addition of perchloric acid (4 ml), concentrated HNO3 (25.00 ml) and concentrated sulphuric acid (2.00 ml) under a fume hood. The contents were mixed and heated gently in a digester (Buchi Digestion unit K-424) at low to medium heat on a hot plate under perchloric acid fume hood and heating was continued until a dense white fume appeared. Heating was continued strongly for half a minute and then allowed to cool followed by the addition of 50 ml distilled water. The solution was allowed to cool and filtered completely with a wash bottle into a Pyrex volumetric flask and then made up with distilled water. The solution was then read on the Atomic Absorption Spectrophotometer. The data collected was subjected to statistical analysis using Analysis of Variance (ANOVA), Principal Component Analysis and Cluster analysis.

RESULTS AND DISCUSSION

Table 1 presents the analysis of variance for various nutritional compositions in 10 landraces of *Capsicum spp.* seeds. Also, genotypic effects were significant at the 1% level ($p \leq 0.01$) for all the measured nutritional elements including Potassium, Calcium, Magnesium, Phosphorus, Iron and Zinc. Low CV values indicate low variability within the experiment, meaning the measurements are reliable.

Table 1. Mean square, coefficient of variation for seed nutritional composition related traits from Analysis of Variance for 10 Pepper Landraces

Source	Df	K (mg/L)	Ca (mg/L)	Mg (mg/L)	P (mg/L)	Fe (mg/L)	Zn (mg/L)
Replication	2	0.01	0.03	0.01	0.02	0.01	0
Genotype	9	28326.87**	5999.00**	10115.42**	804.87**	12.71**	0.44**
Error	18	0.01	0.01	0.01	0.01	0.01	0.00
CV		0.03	0.09	0.07	0.11	3.48	2.28
Total	29						

Df = Degree of freedom, K = Potassium, Ca = Calcium, Mg = Magnesium, P = Phosphorus, Fe = Iron, Zn = Zinc. * Significant at 5% probability; ** Significant at 1% probability

Table 2 compared the mean values of the six nutritional compositions observed in ten *Capsicum spp.* landrace seeds. The highest Potassium content (496.20 mg) is found in F015, followed by F011 (482.25 mg) while the lowest Potassium content (238.31 mg) is observed in F013. F015 stands out with the highest Calcium content (161.52 mg) followed by F020 (156.72 mg), making these genotypes rich in Calcium while the lowest Calcium content (43.64 mg) is in F025. F015 has the highest Magnesium content (201.48 mg), followed by F020 (188.10 mg) while the lowest Magnesium content (62.49 mg) is recorded in F025. F37 has the highest Phosphorus content (90.05 mg), followed by F058 (86.57 mg) while the lowest Phosphorus content (48.95 mg) is observed in F011. F011 contains the highest Iron level (6.77 mg), followed by F37 (3.86 mg) while the lowest Iron content (0.62 mg) is found in F015. The highest Zinc content F011 (1.19 mg) is recorded in and F020 (1.09 mg) while the lowest Zinc content (0.22 mg) is in F010

Table 3 presented the results of the principal component analysis (PCA) of 10 *Capsicum spp*. PC1 and PC2 explain most of the variation with a cumulative percentage of 82.32. PC3 adds another 13.94%, making the first three PCs captured 96.26% of the variability. PC4 made a non-significant contribution to the variation. PC1 is dominated by Potassium, Calcium, and Magnesium, meaning these variables contribute the most to overall variation. PC2 is influenced by Iron and Zinc, suggesting that these two minerals have a distinct variability pattern separate from PC1. Phosphorus contributes negatively to PC1 and loads onto PC3.

Table 2: Means of the six nutritional compositions observed in ten *Capsicum spp*. Landrace seeds evaluated in the study.

Genotype	Potassium	Calcium	Magnesium	Phosphorus	Iron	Zinc
F004	328.66e	49.36h	61.44j	78.37f	1.03ef	0.35f
F010	316.27f	80.47d	121.61d	92.19a	4.36b	0.22h
F011	482.25b	104.61c	186.41c	48.95j	6.77a	1.19a
F013	238.31j	46.92i	68.35g	84.20d	0.82fg	0.44e
F015	496.20a	161.52a	201.48a	51.58i	0.62g	0.28g
F020	463.81c	156.72b	188.10b	55.39h	2.11d	1.09b
F025	248.92i	43.64j	62.49i	73.12g	1.13e	1.02c
F046	268.87h	52.22f	65.38h	82.28e	0.86f	0.28g
F058	302.11g	51.70g	68.92f	86.57c	1.12e	0.89d
F37	351.61d	78.91e	116.33e	90.05b	3.86c	0.42e

Mean followed by the same alphabets along the column are not significantly different from one another

Table 3: Extracted eigenvalues, proportion of variability and loading of the variables for the four principal components for 6 seed elemental variables.

Variables	PC1	PC2	PC3	PC4
K (mg/L)	0.4914	-0.1308	0.0809	0.1023
Ca (mg/L)	0.4630	-0.3444	-0.0060	-0.4920
Mg (mg/L)	0.4925	-0.1386	0.1750	-0.2062
P (mg/L)	-0.4465	-0.0046	0.4063	-0.7267
Fe (mg/L)	0.2335	0.5607	0.7301	0.1665
Zn (mg/L)	0.2182	0.7285	-0.5144	-0.3862
Standard Deviation	1.9660	1.0363	0.9147	0.4038
Proportion of Variance	0.6442	0.1790	0.1394	0.0272
Cumulative Proportion	0.6442	0.8232	0.9626	0.9898
Eigen values	3.8651	1.0738	0.8366	0.1631

Bold values indicate correlation coefficients with value equal to or greater than 0.3 in absolute value

Figure 1 shows the dendrogram which depicts the hierarchical clustering of the mean values of the observed six nutritional elements for 10 pepper landraces and for the three groups distinguished by cluster analysis. The average potassium content (349.70 mg/100g) is highest across all measured traits. The second most abundant mineral is the calcium content (82.61mg/100g) which showed variation among clusters particularly in genotypes F025, F037 and F020. High magnesium content (114.05 mg/100g) in genotype F046 and F011 showed distinctiveness. Moderate level of phosphorus content (74.27 mg/100g) as genotype F004 from cluster1 may be a good source. Iron content (2.27 mg/100g) is low across all genotypes, but only F058 shows the highest and is in cluster1. Zinc content (0.62mg/100g) is also low indicating limited variation across genotypes. The result of the cluster analysis revealed that the 10 *Capsicum spp* landraces were grouped into three clusters with cluster one having five genotypes including F013, F025, F046, F004 and F058. These landraces are closely related, merging early at a low rescaled distance. Cluster II had the least number of genotypes including F010 and F037. These two samples form a distinct subgroup before merging with the larger structure. The last cluster had three genotypes including F015, F020, F011. This group merges separately from the others and remains distinct until the highest linkage level.

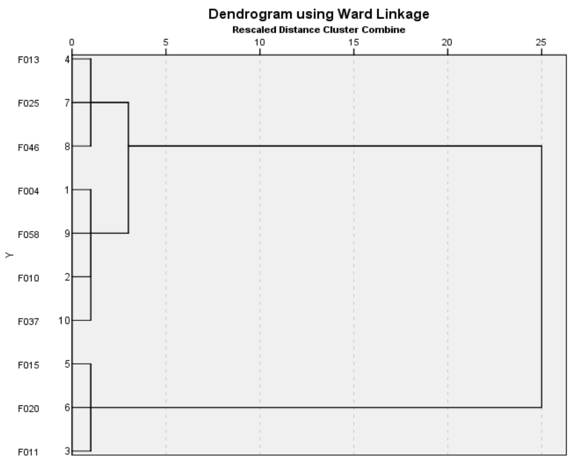


Figure 1: Dendrogram showing the similarities between 10 pepper (*Capsicum spp*) landraces following Ward's cluster analysis based on the squared Euclidean distance.

CONCLUSIONS

The findings indicate substantial genetic variability in mineral composition among the studied pepper landraces. High-mineral genotypes such as F015 (potassium, calcium, and magnesium-rich) and F011 (iron and zinc-rich) could serve as valuable candidates for breeding programs aimed at improving the nutritional quality of *Capsicum spp*. The observed correlations in PCA suggest potential for simultaneous selection of multiple mineral traits to enhance the overall nutritional profile of pepper seeds. Through cluster analysis, the genotypes were grouped into three distinct clusters based on their nutritional profiles. Notably, Cluster 1 (including genotypes F013, F025, F046, F004, and F058) demonstrated superior mineral concentrations, particularly in magnesium, phosphorus, and iron, indicating its potential as a valuable genetic resource for biofortification and nutritional improvement in pepper breeding programs. The diversity observed underscores the importance of genotype selection in enhancing nutritional quality. These findings also provide a foundation for further genetic and agronomic research aimed at addressing micronutrient malnutrition and enhancing the dietary value of pepper crops.

REFERENCES

Abad, M., Martínez, P. F., and Palacios, S. (2005). Composting of bark and olive mill waste for use as a growing medium in ornamental horticulture. *Bioresource Technology*, 96(5), 597-603.

Bosland, P. W. (1996). *Capsicums*: Innovative uses of an ancient crop. Progress in New Crops, 479-487.

Hernandez-Verdugo, S., and Guevara-Gonzalez, R. G. (2015). *Capsicum spp.*: A review of the genus' diversity and economic importance. Genetic Resources and Crop Evolution, 62(6), 851-864.

Pérez-Martínez, A.L., Eguiarte, L.E., Mercer, K.L., Martínez-Ainsworth, N.E., McHale, L., van der Knaap, E., and Jardón-Barbolla, L. (2022). Genetic diversity, gene flow, and differentiation among wild, semiwild, and landrace chile pepper (*Capsicum annuum*) populations in Oaxaca, Mexico. *American Journal of Botany*, 109(7), 1157–1176.

Tripodi, P., Lo Scalzo, R., Ficcadenti, N., and Rosellini, D. (2020). Genotype-driven variation in nutritional and anti-nutritional compounds in pepper seeds. Food Chemistry, 320, 126622.

White, P. J., and M. R. Broadley. (2003). Calcium in plants. *Annals of Botany*, 92(4), 487-511.

Economic yield and mucilage quality of *Corchorus olitorus* L. As affected by varietal difference, fertilizer application rates and age at harvest

[1]Olorunsogo G. O., [1]Fabunmi, T. O., [1]Adigbo, S. O., [2]Oduwaye, O. A and [3]Fadeyi, O. J.

[1]Department of Plant Physiology and Crop Production, [2]Department of Plant Breeding and Seed Technology,
[3]Institute of Food Security, Environmental Resources and Agricultural Research (IFSERAR)
Federal University of Agriculture, Abeokuta, Ogun State, Nigeria

ABSTRACT

Economic yield is important in crop production, the quality of harvested crop is also of prime importance as it determines acceptability by the consumer. Mucilage quality is one of the most preferred quality attribute in the consumption of Corchorus olitorus L. This study therefore evaluated the effect of three rates of Nitrogen (20, 30, 40 kgN/ha) sourced from poultry manure and two control comprising of 0 Kg N/ha and 40 kgN/ha sourced from urea fertilizer, three age at harvest (5, 6, and 7 WAP), on the yield and mucilage quality of two varieties (oniyaya and eletieku) of Corchorus olitorus. The 5 x 3 x 2 factorial experiment arranged in Randomized Complete Block Design (RCBD) was replicated three times**.** There was significant ($p \leq 0.05$) interaction between rates of fertilizer application and age at harvest on the yield (ton/ha), and mucilage quality (cP) of C. olitorus. There was no significant ($p \leq 0.05$) varietal difference observed. It is concluded that for optimal economic yield and mucilage quality of Corchorus olitorus, harvesting should be done at 6 WAP, with application of 40 kgN/ha from poultry manure.

Key words: ……………

***Corresponding author**: fabunmito@funaab.edu.ng

INTRODUCTION

Corchorus olitorus L. is an angiosperm, an erect dicot plant from the Tilaceae family. The crop is native to both the tropics and subtropics regions of the world and its edible leaves are served as traditional dishes in the Middle East, parts of Asia and Africa. It is commonly called *ewedu* among the Yorubas, *ayoyo* in Hausa, *ahuara* in lgbo; and in English; Jew's mallow/Jute leaf (Ekaette, *et al.,* 2024). *C. olitorus* plants are erect herbaceous plants that are 2-4 meters in height with leaves that are alternate and bear capsule-like fruits encapsulating about 25-40 seeds *C. olitorus* as leafy vegetable is accredited with possession of high nutritional values of essential nutrients like protein, calcium, phosphorous, iron and other important components such as vitamins A, B complex, C, fiber, carbohydrate, fat and a high calorific value (Sanni and Adesina, 2012). The mucilage quality of *Corchorus olitorus* is a notable attribute that adds value to this plant. It is not only responsible for the plant's culinary versatility but also, its potential health benefits. The mucilage's unique properties, including its texture, nutrient content, and traditional uses, makes corchorus a valuable and versatile plant in both culinary and medicinal contexts (Islam, 2013). Corchorus responds well to organic compost and animal manures which improve yields and maintain soil fertility, however the rates of organic nutrients applied depends largely on the quality of the organic manure and the fertility status of the soil as well as other soil factors (FFD, 2017).

Although, the high nutritional value and importance of *C. olitorius* is widely publicized, there is still limited findings about the factors that are responsible for the optimum yield combined with mucilage quality of the crop. The aim of this study is therefore, to evaluate the economic yield and mucilage quality of *Corchorus olitorius* as influenced by varietal difference, rates of Nitrogen application from organic source and age at harvest. The study was conducted to determine the economic yield response and mucilage quality of Jute mallow under different rates of N from poultry manure and urea.

MATERIALS AND METHODS

The experiment was conducted at the Teaching and Research Farms of the Federal University of Agriculture, Abeokuta, Ogun State, located between latitude 7° 21'N and 7° 22'N and longitude 3° 26'E and 3° 27'E and lies within a forest-savanna transition zone in southwestern part of Nigeria between February to March, 2025. The experimental field area was ploughed and harrowed mechanically, the soil samples were collected and analyzed to determine the physical and chemical properties of the soil, vegetable beds measuring 1m X 1m were constructed according to the plot dimension, followed by planting using line drill method, spacing 25 cm x 25 cm. There were *three* rates of Nitrogen (20, 30, 40 kgN/ha) sourced from poultry manure and two control comprising of 0 Kg N/ha and 40 kgN/ha sourced from urea fertilizer, three age at harvest (5, 6, and 7 WAP) and two varieties (oniyaya and eletieku) of *Corchorus olitorus*. The 5 x 3 x 2 factorial experiment arranged in randomized complete block design was replicated three times. Weeds were removed manually to eliminate competition with the plants. Harvesting was done at 5th, 6th, and 7th week after planting, and mucilage test was carried out after each harvest and data collected obtained were subjected to Analysis of Variance using GENSTAT analysis software package, significant means were separated using Least Significant Difference (LSD) at 5% probability level.

RESULTS AND DISCUSSION

Table 1 shows the result of soil analysis carried out on the experimental field. The pH of the soil is near neutral with moderate soil nitrogen and the soil is sandy loam averagely adequate for production of most crop and precisely Jews mallow in this study. Table 2 presents the chemical analysis of organic manure used in the study. The target nutrient N in this material was 3.69% with substantial amount of P, K and other micro nutrients.

Table 1: Physical and chemical properties of the soil from the experimental Site

Parameters	Value
pH	6.85
Sand (%)	65.2
Clay (%)	4.5
Silt (%)	30.3
Textural Class	Sandy loam
N (%)	0.22
Org. C (%)	0.87
Org. M (%)	1.48
Av. P (mg/kg)	18.25
Ex. A (mEq/100g)	0.42
Na (cmol/kg)	0.32
K (cmol/kg)	0.49
Ca (cmol/kg)	0.29
Mg (cmol/kg)	0.35

Table 2: Nutrient composition of the poultry manure used for the study

Parameters	Value
pH	7.03
Total N (%)	3.685
Org. C (%)	40.10
Org. M (%)	69.13
Av. P (mg/kg)	18.64
Na (cmol/kg)	28.916
K (cmol/kg)	26.652
Ca (cmol/kg)	36.112
Mg (cmol/kg)	8.125
Fe (mg/kg)	161.564
Cu (mg/kg)	1.089
Mn (mg/kg)	3.245
Zn (mg/kg)	2.816
E.C µS/cm	9060

Effect of age at harvest, rate of fertilizer, and variety on mucilage (cP) and yield (ton/ha) of Corchorus olitorus

Table 3 presents the effect age at harvest, rate of fertilizer, and variety on the mucilage and yield of *Corchorus olitorus*. The time of harvest significantly ($p \leq 0.05$) affected the yield (ton/ha) obtained from the plant, the highest yield was obtained at 7 weeks after planting (WAP), while the lowest was obtained at 5 weeks after planting. The mucilage quality (cP) was significantly ($p < 0.05$) affected by the age at harvest, and the lowest mucilage was observed at 7 WAP and the highest at 6 WAP. The rate of fertilizer applied also significantly ($p \leq 0.05$) affected the yield and mucilage quality of *C. olitorus*, there was gradual increase in yield and mucilage quality with increasing fertilizer application rate with the highest value for both observed at 40 kgN/ha organic manure application, varieties also significantly affected the yield but not the mucilage quality (cP).

Table 3: Effect of age at harvest, rate of Nitrogen, and variety on mucilage and yield of *Corchorus olitorus*

Treatment	Yield (ton/ha)	Mucilage (cP)
Age at Harvest		
5 WAP	5.1	247.73
6 WAP	8.5	382.20
7 WAP	11.8	235.37
LSD	0.05	1.33
Rate of Nitrogen		
0 kgN/ha (control)	5.6	181.83
20 KgN/ha PM	6.4	203.06
30 KgN/ha PM	8.7	318.00
40 KgN/ha PM	11.0	462.28
40 KgN/ha Urea	10.7	268.94
LSD	0.08	1.71
Variety		
Oniyaya	8.0	284.84
Eletieku	8.9	288.80
LSD	0.09	1.98
Interactions		
Varieties*Rate	0.11	2.35
Varieties*Age	0.08	1.85
Rates*Age	0.12	2.90
Varieties*Rate*age	0.17	4.08

WAP = Weeks After Planting; PM= Poultry manure

Interaction of fertilizer rate and age at harvest on the mucilage (cP) of Corchorus olitorus.

Table 4 shows the interaction of rate of fertilizer and age at harvest on the mucilage (cP) of *C. olitorus*. The highest mucilage quality was obtained when harvested at 6 WAP when 40 kgN/ha organic manure (OM) was applied. The lowest mucilage value was observed at 5 WAP age at harvest and across 0, 20, and 30 kgN/ha rate of fertilizer application. At 40 kgN/ha organic manure and across 5, 6, and 7 WAP age at harvest mucilage value (cP) was highest and comparatively low for the same rates of N supplied using urea across all age at harvest. This implies that for better mucilage quality of *C. olitorus*, application of organic manure is best.

Table 4: Interaction of rates of Nitrogen application and age at harvest on mucilage (cP) of *Corchorus olitous*

Rate of Nitrogen	Age at Harvest		
	5 WAP	6 WAP	7 WAP
0 kgN/ha (control)	143.8	243.0	158.7
20 KgN/ha PM	152.8	323.5	182.8
30 KgN/ha PM	230.0	452.8	245.3
40 KgN/ha PM	485.7	553.8	347.3
40 KgN/ha Urea	226.3	337.8	242.67
LSD		2.89	

WAP = Weeks after Planting; PM= Poultry manure

Interaction of fertilizer rate and age at harvest on the yield (ton/ha) of Corchorus olitorus

Table 5 presents the interaction of different rates of fertilizer application and age at harvest on yield of *C. olitorus*. It shows that there is an increased yield with higher rate of fertilizer application and age at harvest. The highest yield value was obtained at combination of 7 WAP and 40 kgN/ha organic fertilizer application, although application of 40 kgN/ha of urea produced highest yield in 5 WAP age at harvest, but it was relatively lower than yield output of the same nitrogen rate from Poultry manure at 6 and 7 WAP age at harvest, implying that organic fertilizer application might be more beneficial in the long run than inorganic fertilizer. This corroborates the report of Sisay and Sisay, (2019) that one of the most significant benefits of manure as an organic nutrient source is the potential to maintain or increase soil organic matter levels.

Table 5: Interaction of rates of Nitrogen application and age at harvest on yield (cP) of *Corchorus olitorus*

Rate of Fertilizer	Age at Harvest		
	5 WAP	6 WAP	7 WAP
0 kgN/ha (control)	2.7	5.7	8.3
20 KgN/ha PM	3.2	6.3	9.7
30 KgN/ha PM	4.7	10.0	12.3
40 KgN/ha PM	7.4	12.2	14.4.
40 KgN/ha Urea	7.6	10.6	14.2
LSD		0.12	

WAP = Weeks after Planting; PM= Poultry manure

Interaction of rates of fertilizer application, age at harvest, and varieties on mucilage (cP) of Corchorus olitorus

Table 6 presents the interactive effect of age at harvest, rate of fertilizer, and variety on the mucilage quality (cP) of *Corchorus olitorus.* It showed highest mucilage value (555) was obtained at 6 WAP, 40 kgN/ha PM from *oniyaya* variety, and lowest mucilage value (143) was obtained at 5 WAP in the control from *eletieku* variety.

Interaction of rates of fertilizer application, age at harvest, and varieties on yield (ton/ha) of Corchorus olitorus

Table 7 is a presentation of the interaction of rate of fertilizer application, age at harvest and variety as it affected the yield (ton/ha) of jute mallow. Highest yield value (14.8) was obtained at 40 kgN/ha PM, seventh week after planting from *eletieku* variety, and lowest yield value (2.6) was obtained in the control (0kgN/ha), fifth week after planting also from *eletieku* variety.

CONCLUSION

This study concludes that rates of fertilizer application and age at harvest significantly influenced the yield, and mucilage quality of *Corchorus olitorus.* While varietal differences were observed, their effects were less pronounced compared to those of the other treatments. Notably, applying the same fertilizer of 40 kgN/ha from different sources – organic and inorganic, resulted in distinct outcomes in terms of mucilage quality and overall yield. This highlights the importance of fertilizer type in optimizing production. The yield obtained at 6 weeks after planting (WAP) was comparable to that at 7 WAP and notably higher than the yield at 5 WAP. This suggests that, for optimal results in the cultivation of *Corchorus olitorus,* applying 40 kgN/ha sourced from poultry manure and harvesting at 6 WAP offers the most effective combination in terms of economic yield and mucilage quality.

Table 6: Interaction of rates of fertilizer application, age at harvest, and varieties on mucilage (cP) of *Corchorus olitorus*

Age at Harvest	Rate of Fertilizer	Variety	
		Oniyaya	Eletieku
5 WAP	Control	145	143
	20 KgN/ha PM	153	153
	30 KgN/ha PM	265	247
	40 KgN/ha PM	436	535
	40 KgN/ha Urea	223	230
6 WAP	Control	255	231
	20 KgN/ha PM	274	373
	30 KgN/ha PM	473	432
	40 KgN/ha PM	555	553
	40 KgN/ha Urea	353	323
7 WAP	Control	163	154
	20 KgN/ha PM	178	188
	30 KgN/ha PM	247	243
	40 KgN/ha PM	342	352
	40 KgN/ha Urea	211	274
$LSD_{0.05}$		4.08	

WAP = Weeks after Planting; PM= Poultry manure

REFERENCES

Ekaette S. U., Arit U., Sylvester C O., Umiom E., Pascal W. (2024) Phytochemistry of *Corchorus olitorius* Leaf Cultivated in Calabar, Cross River State, Nigeria. *International Research Journal of Modernization in Engineering Technology and Science.* e-ISSN: 2582-5208.

Table 7: Interaction of rates of fertilizer application, age at harvest, and varieties on yield (ton/ha) of *Corchorus olitorus*

Age at harvest	Rate of Fertilizer	Variety	
		Oniyaya	Eletieku
5 WAP	Control	2.8	2.6
	20 KgN/ha PM	3.3	3.1
	30 KgN/ha PM	4.4	5.0
	40 KgN/ha PM	7.3	7.4
	40 KgN/ha Urea	7.6	7.7
6 WAP	Control	4.9	6.5
	20 KgN/ha PM	5.7	6.9
	30 KgN/ha PM	8.9	9.1
	40 KgN/ha PM	10.4	11.8
	40 KgN/ha Urea	9.3	11.5
7 WAP	Control	7.7	9.0
	20 KgN/ha PM	8.3	11.0
	30 KgN/ha PM	12.0	12.7
	40 KgN/ha PM	14.0	14.8
	40 KgN/ha Urea	14.1	14.2
$LSD_{0.05}$		0.17	

WAP = Weeks after Planting; PM= Poultry manure

FFD (Federal Fertilizer Department) (2017). Fertilizer use and management practices for Nigeria. Federal Ministry of Agriculture and Rural Development, Abuja, Nigeria. 2012;1-215.

Islam M (2013). Biochemistry, Medical and food values of Jute leaf: A review. *International journal of enhanced Research in science technology and Engineering*, vol.2 (2); pp: 35-44. Retrieved from http://www.erpublications.com

Sanni K. O. and Adesina J. M. (2012). Agronomic Performances of *Corchorus olitorus* ("Ewedu") As Influenced by Poultry Manure And Npk 15 15-15 Fertilizer In Ikorodu Agro-Ecological Zone Of Nigeria. *World Rural Observations*, 4(1)….

Sisay A. and Sisay T. (2019). The Principal Role of Organic Fertilizer on Soil Properties and Agricultural Productivity - A Review. *Agricultural Research and Technology: Open Access Journal.* Volume 22 Issue 2 - August 2019 DOI: 10.19080/ARTOAJ.2019.22. 556192

Hedge formation of *Duranta* Species for Landscaping as influenced by Number of Branches

Owolabi, C. O.*, [1]Olajire O. A., Ilem, D. O. and Olosunde O. M.
Department of Horticulture, Federal University of Agriculture Abeokuta, Nigeria

ABSTRACT
This study evaluated the impact of initial branch number on the establishment and vegetative performance of *Duranta erecta* and *Duranta repens* as hedge species for landscape use. The experiment was laid out as a 2 × 3 factorial in a Randomized Complete Block Design (RCBD) with three replicates. Treatments included two species (*D. erecta* and *D. repens*) and three branch levels: no branches, two branches, and four branches. Data collected biweekly over 14 weeks included survival rate, plant height, number of leaves, branches, and canopy diameter. Results revealed 100% survival in all treatments, suggesting both species possess high transplant resilience. *D. repens* consistently outperformed *D. erecta* in height, leaf production, and canopy spread. Plants with four branches recorded significantly higher vegetative growth metrics than those with fewer branches. However, branch number had no significant effect on canopy diameter. These findings suggest that transplanting *D. repens* with four branches may optimize hedge performance in urban landscapes.

Key words: *Duranta erecta*, *Duranta repens*, hedge establishment, transplanting, urban landscaping, branch number

***Corresponding Author**: tolusol910@gmail.com

INTRODUCTION
Hedge plants contribute to biodiversity, aesthetics, and microclimate regulation in landscapes. However, optimal transplanting conditions for hedge success, including shoot architecture, are not fully established. More comprehensive guidelines for hedge plant transplantation. The number of branches on a hedge plant at the time of transplanting is a significant factor that influences its ability to establish itself in a new environment. Existing research suggests that more branches can enhance photosynthetic capacity and improve survival rates, but excessive branching may lead to resource allocation problems that hinder root development and increase water stress (Davis and Lanouette, 2017; Michaels and Carr, 2019). The optimal number of branches for successful establishment remains a subject of debate, with studies indicating that a balance between root development and branching is crucial for plant survival and growth (Ma et al., 2020). Additionally, many studies have been conducted under controlled conditions in nurseries or greenhouses, where variables such as soil type, climate, and water availability are carefully regulated. These conditions do not necessarily reflect the challenges faced by transplanted plants in real-world environments, where these factors can vary significantly (Wilkins *et al*., 2020). Furthermore, the optimal balance between root development and branching remains unclear. While studies like those of Ma *et al.* (2020) suggest that a moderate number of branches may promote better establishment, there is still no consensus on what constitutes the ideal branching structure for various plant species and environments. Research that takes into account different environmental conditions, plant species, and transplanting techniques is needed to provide more comprehensive guidelines for hedge plant transplantation.

Further research is needed to fill the gaps in our understanding, particularly in real-world environments, and to develop evidence-based guidelines for transplanting hedge plants effectively. This study focuses on the role of initial branch number in post-transplant success of *Duranta* species popular hedge plants in tropical urban design.

MATERIALS AND METHODS

The experiment was conducted at the Horticulture Department Nursery, FUNAAB. Treatments involved two *Duranta* species (*erecta* and *repens*) and three branch number levels: 0, 2, and 4 branches as shown in Plate 1. The design was in randomized complete block design with three replicates. Parameters measured biweekly included survival rate, plant height, number of leaves and branches, canopy diameter, and aesthetic features (photo-documented). The experimental area was cleared of existing vegetation and debris. The soil was prepared by digging uniform holes to accommodate the different transplanting treatments. Spacing between holes was remain consistent across all treatments to ensure uniform growth conditions (40cm intra spacing) as recommended by owolabi *et al.*

(2023). The plants were transplanted into the prepared holes, and care was taken to ensure that all plants receive the same initial watering and handling to reduce transplant shock. Post-Transplant Management: After transplanting, all plants received consistent care to promote establishment in terms of weeding and watering as need arose. Data were analyzed using ANOVA; Tukey's HSD were used to separate means at 5% significance level.

RESULT AND DISCUSSION

Survival Rate

The survival rate across all treatments was 100%, irrespective of species (*Duranta erecta* or *Duranta repens*) and the number of branches at transplanting. This indicates that both species possess exceptional resilience to transplant stress under the experimental conditions. The zero Least Significant Difference (LSD) values at all time points confirm that survival was not significantly affected by plant species and number of branches (Figs. 1a & 1b). This suggests that the environmental conditions such as soil type, watering regime, and transplanting technique were optimal and consistently maintained. These results align with Wilkins et al. (2020), who emphasized the importance of controlled external factors in enhancing transplant success.

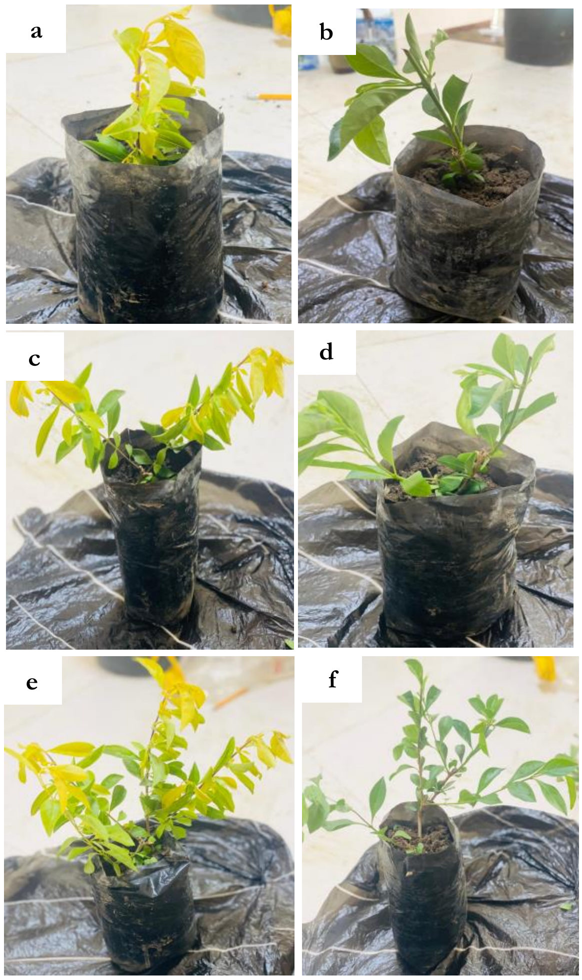


Plate 1: A and B: *D. erecta* and *D. repens* with no branch, C and D: *D. erecta* and *D. repens* with two branches, E and F: *D. erecta* and *D. repens* with four branches

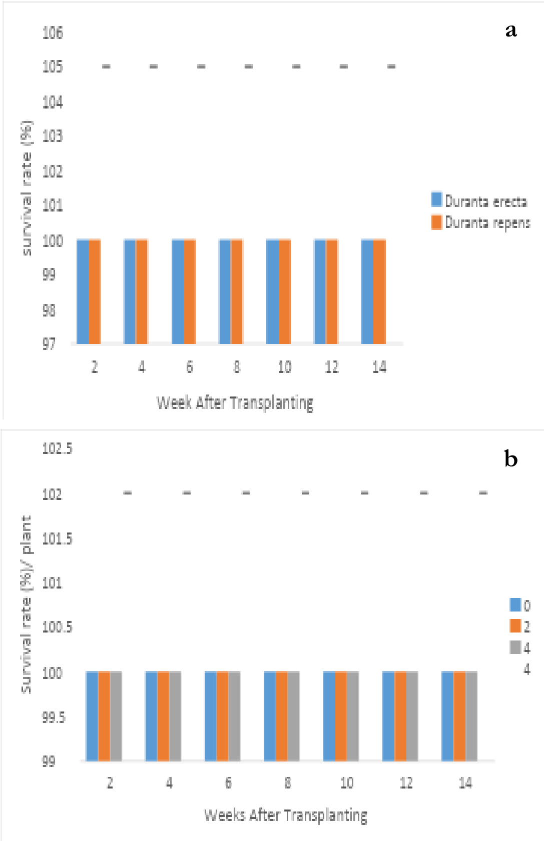


Figure 1: Survival rate as affected by: (a) hedge species weeks after transplanting, (b) number of branches weeks after

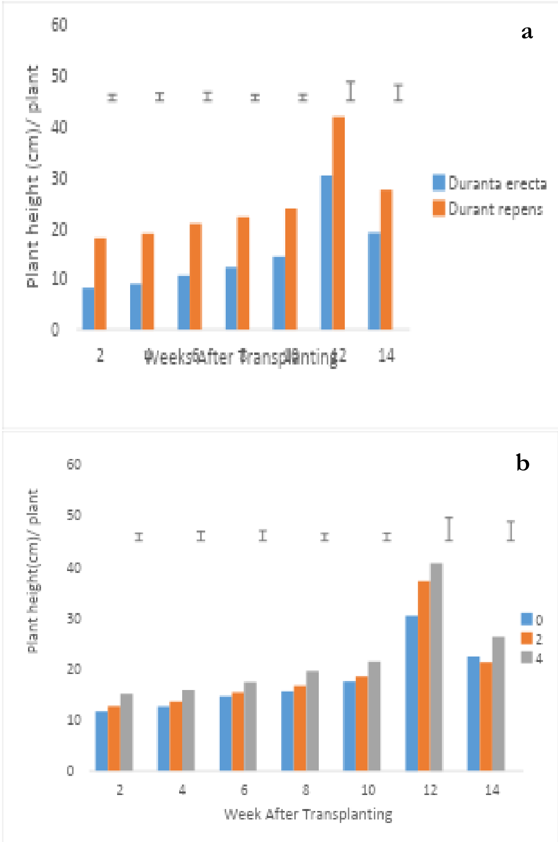


Figure 2: Plant height as influenced by (a) hedge species (b) number of branches

Plant height

Plant height showed significant variation based on both species and branch number. *Duranta repens* demonstrated superior vertical growth compared to *D. erecta*, with a final height of 41.83 cm by the 12th week, compared to 30.25 cm for *D. erecta*. Among branch treatments, plants with four branches consistently outperformed others across all time intervals, reaching 40.62 cm at week 12 compared to 37.12 cm (2 branches) and 30.38 cm (no branches) (Figs .2a & 2b). These findings indicate that increased initial branching supports vertical growth, likely due to enhanced photosynthetic area and energy accumulation. This is consistent with Michaels and Carr (2019), who noted that increased branch density correlates with greater growth potential due to elevated carbohydrate production and shoot vigor.

Number of Leaves

The number of leaves followed a similar trend to plant height. *D. repens* produced significantly more foliage than *D. erecta* at every measurement point, peaking at 364.4 leaves versus 302.1 at 14 weeks (Fig. 3a). In terms of branch number, plants with four branches recorded the highest leaf count (375.6 leaves), followed by two branches and zero branches (287.5 leaves) (Fig.3b). The observed increase in leaf production with branch number suggests that a higher initial branch count stimulates rapid canopy development and foliage density. These results reinforce the conclusion of Ma et al. (2020) that balanced shoot development supports robust photosynthetic function and improves transplant recovery.

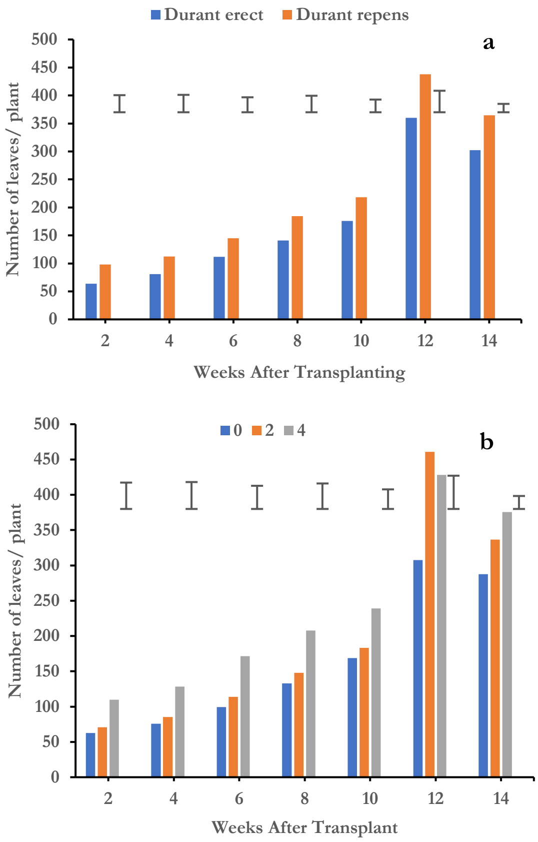


Figure 3: Number of leaves as influenced by (a) hedge species (b) Number of branches

Canopy Diameter

Canopy diameter was significantly influenced by species but not by the number of branches. *D. repens* showed broader canopy spread (296 cm at 16 weeks) compared to *D. erecta* (256 cm) (Fig. 4a). However, the differences among the three branching treatments were statistically non-significant at both 14 and 16 weeks. This indicates that canopy expansion is more strongly governed by genetic traits and species-specific growth habits than by initial branching. The lack of a branching effect on lateral spread may also reflect compensatory growth, where plants with fewer initial branches redirect energy to lateral expansion after root establishment.

Branch proliferation was highest in plants that were initially given four branches. This suggests a compounding effect where early branching stimulates further shoot initiation (Fig. 4b). Plants with no branches at transplanting showed delayed or minimal branching throughout the study period. This implies that structural form at transplanting plays a major role in shaping overall plant architecture during establishment. Davis and Lanouette (2017) argued similarly that branch architecture can pre-condition plants for post-transplant performance.

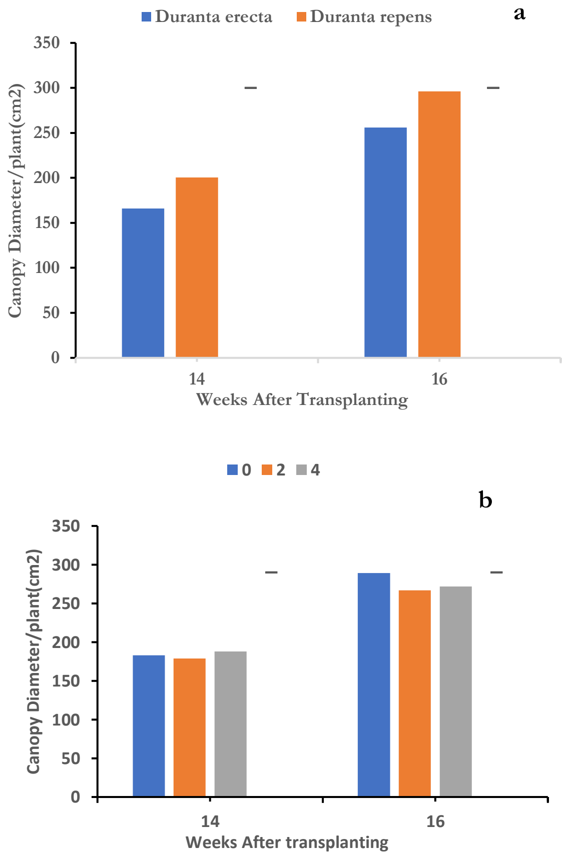


Figure 4: Canopy diameter/plant as influenced by (a) hedge species (b) Number of branches

Aesthetic Progression

Visual appeal, which is vital in landscaping, plants with no branches often lagged in developing a balanced canopy and appeared sparse in both species particularly in the early weeks (Plate 2-3). Photographic documentation revealed that plants with four branches had fuller foliage, better symmetry, and more uniform structure throughout the study with D. *repens* having denser foliage and faster canopy formation (Plate 4-7). These observations align with urban greening goals, as aesthetically pleasing hedges enhance property value, user experience, and biodiversity (Horvat *et al.*, 2024).

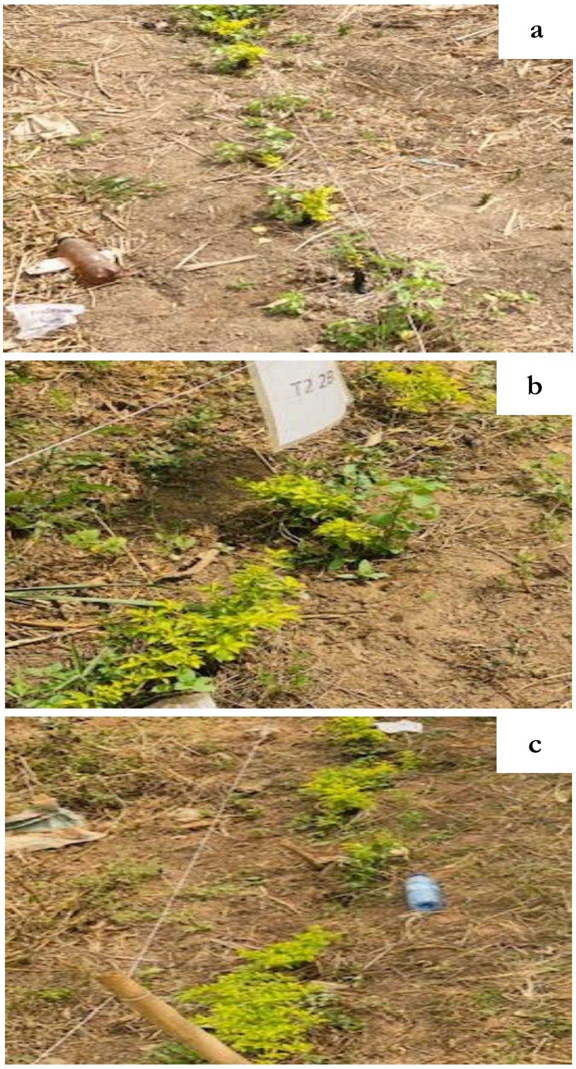


Plate 2: Shows the pictorial view of the plant growth of Duranta *erecta* at 9 WAT: (a) Plant with no branch (b) Plant with two branches (c) Plant with four branches

CONCLUSION

The study underscores the importance of selecting suitable hedge species and preparing plants with an optimal branch structure at transplanting. *D. repens* showed stronger adaptability and vigor, making it more suitable for rapid hedge establishment.

A four-branch structure at transplanting enhanced vegetative performance without negatively affecting survival. However, for attributes such as canopy spread, species selection plays a more critical role than initial branch number.

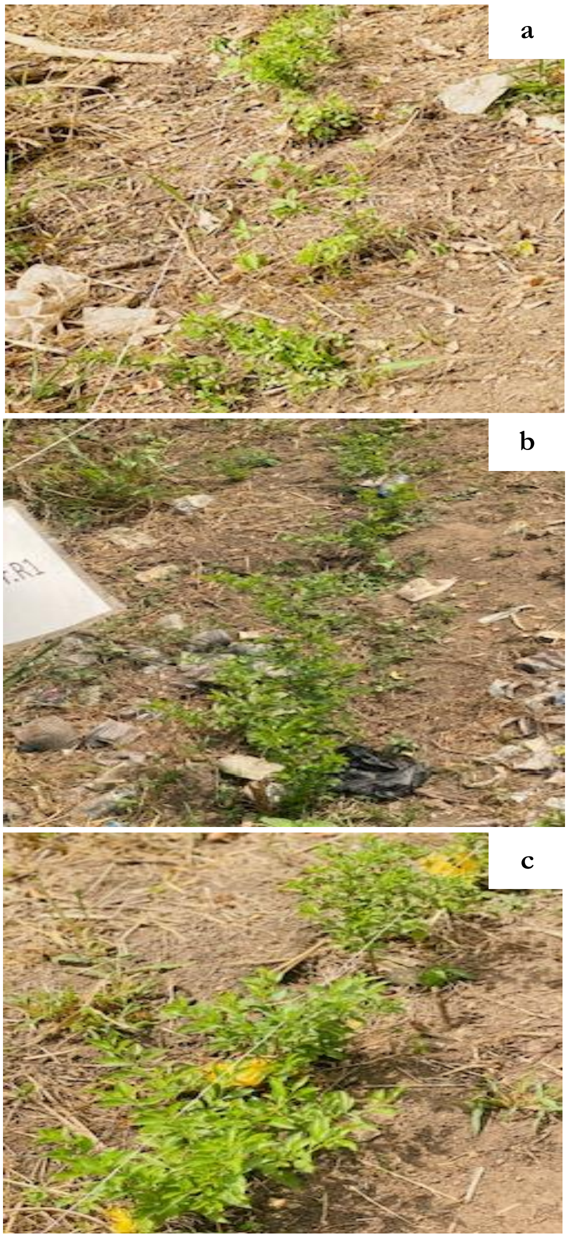


Plate 3: Shows the pictorial view of the plant growth of *Duranta repens* at 9 WAT: (a) Plant with no branch (b) Plant with two branches (c) Plant with four branches

These findings provide practical recommendations for horticulturists and landscapers: choose *Duranta repens* over *D. erecta* where quick foliage cover and visual impact are priorities, prepare hedge plants with four branches at transplanting to maximize early growth and foliage density.

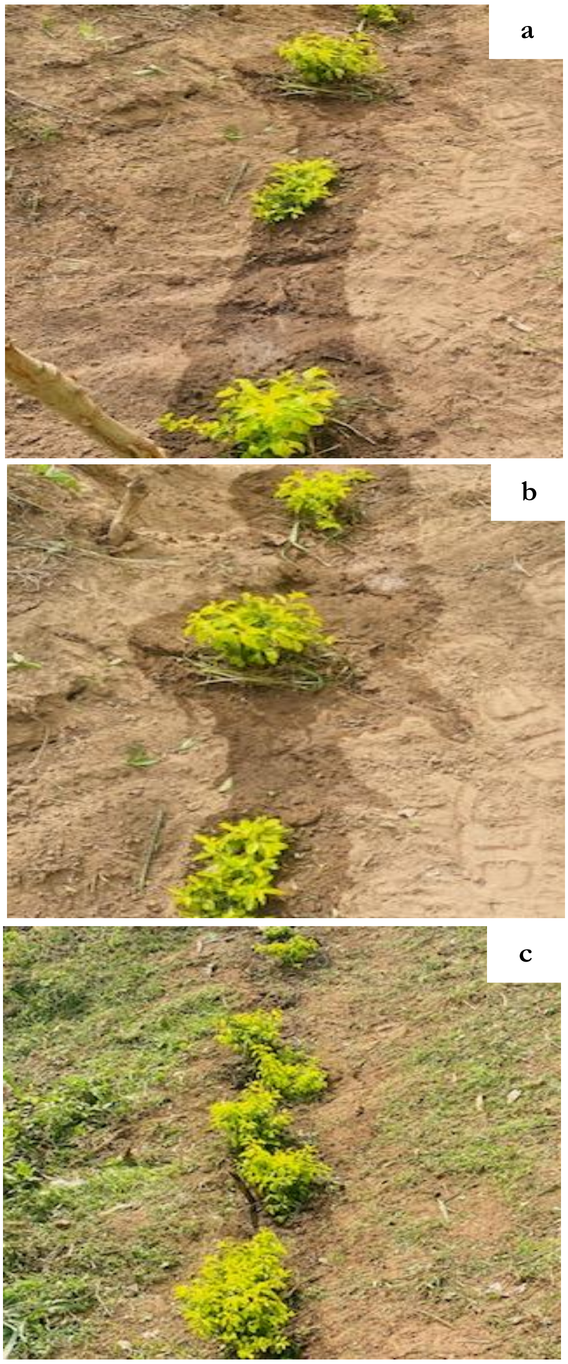


Plate 4: Shows the pictorial view of the plant growth of *Duranta erecta* at 18 WAT: (a) Plant with no branch (b) Plant with two branches (c) Plant with four branches

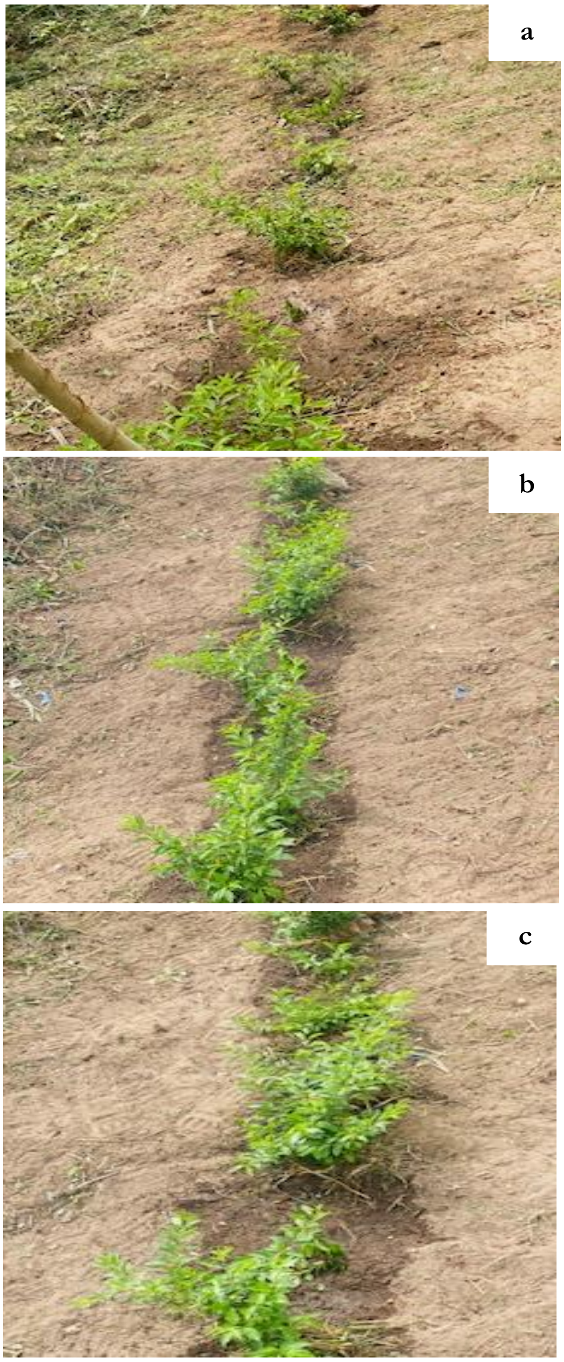


Plate 5: Shows the pictorial view of the plant growth of Duranta repens at 18 WAT: (a) Plant with no branch (b) Plant with two branches (c) Plant with four branches

REFERENCES

Burt, C., Davis, L., and Michaels, R. (2021). The impact of branch number on the stress tolerance of transplanted plants. *Journal of Horticultural Science*, 38(2), 345–359.

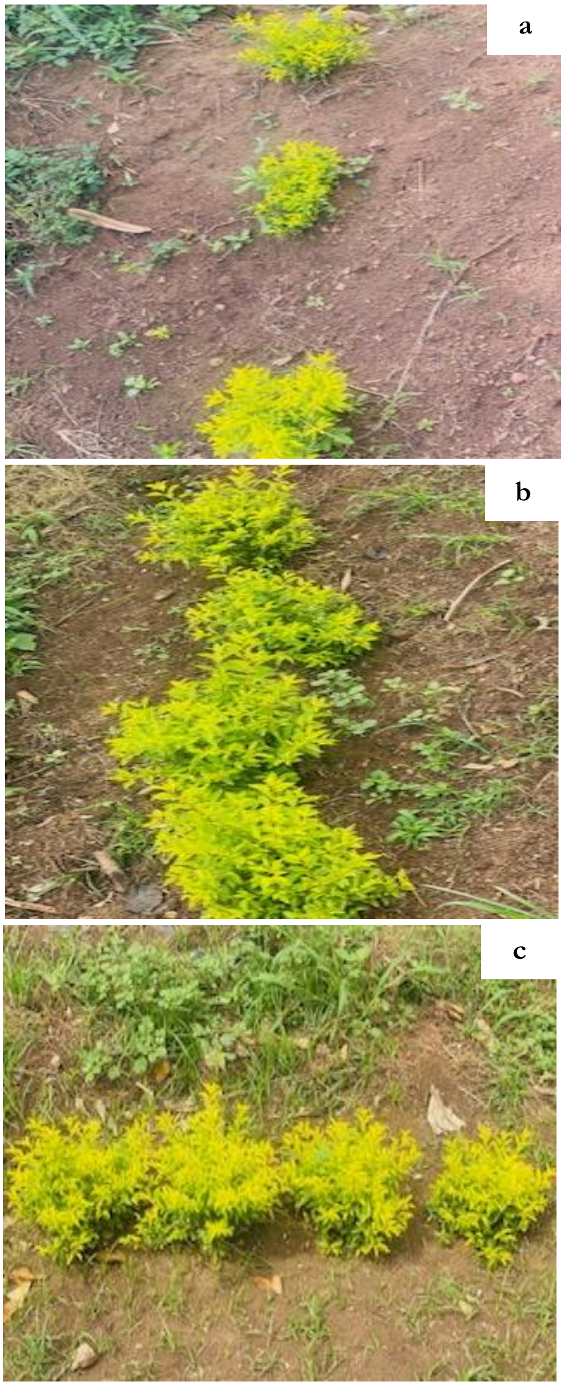


Plate 6: Shows the pictorial view of the plant growth of Duranta ereta at 24 WAT: (a) Plant with no branch (b) Plant with two branches (c) Plant with four branches

Davis, M. and Lanouette, J. 2017. Branch structure and post-transplantation survival in woody plants. *Plant Biology Review*, 12(1): 78–94.

Horvat, E., Šipek, M., & Sajna, N. (2024). Urban hedges facilitate spontaneous woody plants. *Urban Forestry & Urban Greening*, 96, 128336.

Plate 7: Shows the pictorial view of the plant growth of *Duranta repens* at 24WAT: (a) Plant with no branch (b) Plant with two branches (c) Plant with four branches

Lesaint, L., Viaud, V. and Menasseri-Aubry, S. (2023). Influence of soil properties and land use on organic carbon storage in agricultural soils near hedges. *Soil Use and Management*, 39(3): 1140–1154.

Lo Piccolo, E., Ceccanti, C., Lauria, G., Santonocito, G., Rosellini, I., Pezzarossa, B., Guidi, L., Laudicina, V. A., Baglieri, A., Remorini, D., Massai, R., & Landi, M. (2024). From lava to leaf: Physiological responses and trace element mobility in *Tilia cordata* L. trees grown in volcanic ash amended urban soil. *Urban Forestry & Urban Greening*, 99, 128458.

Ma, Q., Liu, T. and Zhang, S. 2020. Effects of branch number on root development and plant establishment in hedge plants. *Horticultural Research Journal*, 29(4): 289–305.

Michaels, R. and Carr, S. 2019. Photosynthetic capacity and plant development in response to branching patterns. *Plant Growth and Structure Review*, 45(1): 112–126.

Nikolov, M., & Melnyk, M. (2019). The role of root mass and structure in successful plant establishment. *Journal of Plant Physiology and Ecology*, 18(3), 201–215.

Owolabi, C. O., Odusanya, A. I., Olosunde , O. M., Odedina, J. N. and Bodunde, J. G. 2023. Growth characteristics and post trimming regrowth potential of tropical and sub-tropical landscape hedge plants in response to spacing. *Annals of Tropical Research Journal* 45(1): 1-21.

Thompson, R., & Chapman, D. (2018). Transplanting techniques and the role of environmental factors in plant establishment. *Agriculture and Horticulture Review*, 52(6), 529–543.

Wang, T., Sun, D., Xiong, W., Kuang, F., Xue, K., Shi, M., Xi, D., & Zhu, D. (2024). Impact of root-stem coupling damage from mechanical transplanting on the growth of large rice seedlings. *Plant Growth Regulation*.

Wilkins, J., O'Connor, P. and Stein, A. 2020. Hedge plant establishment: Factors influencing root growth and plant survival. *Horticultural Science Today*, 27(7): 511–525.